Radiological Health Data and Reports

VOLUME 10, NUMBER 10

OCTOBER 1969

(Pages 421–474)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimete (s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegr tions per second	
eV	electron /olt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga ele tron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g=2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie=2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 10, October 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

Page

REPORTS

Experience of the State of Illinois Department of Public Health Following the Enactment of a Laser System Registration Law 421

Russell W. Courtney

A Comparison of the Cesium-137 Content of Milk and People from 19 Dairy Farms in Utah 427

R. D. Lloyd, C. W. Mays, R. C. Pendleton, and *D. O. Clark*

DATA

SECTION I. MILK AND FOOD 435

Milk Surveillance, June 1969 435

Radiostrontium in Milk, January-December 1968, *HASL* 445

Food and Diet Surveillance 446

1. Radionuclides in Institutional Diet Samples, January–March 1969 and Annual Summary 1968, *BRH* and *FDA* .. 446

SECTION II. WATER 451

Gross Radioactivity in Surface Waters of the United States, March 1969, FWPCA 452

CONTENTS—continued

Page

SECTION III. AIR AND DEPOSITION 455

Radioactivity in Airborne Particulates and Precipitation 455

1. Radiation Alert Network, June 1969, *PHS* 456

2. Canadian Air and Precipitation Monitoring Program, June 1969 459

3. Mexican Air Monitoring Program, September–October 1968 460

4. Pan American Air Sampling Program, June 1969, *PAHO* and *PHS* 461

5. Fallout in the United States and Other Areas, January–June 1968, *HASL* 462

6. Plutonium in Airborne Particulates and Precipitation, April–June 1968, *PHS* 464

SECTION IV. OTHER DATA 467

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 467

1. Lawrence Radiation Laboratory, January–December 1968 467

2. Shippingport Atomic Power Station, January–December 1968 471

Reported Nuclear Detonations, September 1969 473

Synopses iii

Guide for Authors ..... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

John C. Villforth
Director
Bureau of Radiological Health

BOARD OF EDITORIAL ADVISORS

Dr. Harold O. Wyckoff
Department of Defense

Dr. Milton W. Lammering
Department of the Interior

Dr. Maurice H. Frere
Department of Agriculture

Dr. Carl O. Muehlhause
Department of Commerce

Robert E. Simpson
Food & Drug Administration, DHEW

Dr. Martin B. Biles
Atomic Energy Commission

MANAGING DIRECTOR
John G. Bailey
Director, Office of Information

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt Feldmann
Editorial Assistants	Jacqueline J. Copp Mary Nesdore
Illustrator	Marylee Hill

Address correspondence to the Editor, *Radiological Health Data and Reports*, Bureau of Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration • Bureau of Radiological Health

Reports

Experience of the State of Illinois Department of Public Health Following the Enactment of a Laser System Registration Law

Russell W. Courtney[1]

The experience of the State of Illinois Department of Public Health, following the enactment of a laser registration law, is presented. The priorities suggested for the inspection of laser systems are (1) high intensity laser systems applied in industrial processes, (2) lower intensity laser systems used in outdoor processes that could potentially expose the general public, (3) lasers used in research institutions, and (4) lasers used as high school and college teaching instruments.

At the time of this report, only one accident had been reported to the Department of Health. This accident was a case of electrical shock in which there was no serious injury or loss of work time for the employee.

Illinois enacted the first law in the country relating to laser radiation. This act was known as the Laser System Registration Law.[2] The law requires every operator of a laser system to register such system with the Director of Public Health prior to January 1, 1968, and "to report to the Department any accidental injury to any individual in the course of use, handling, operation, manufacture, or discharge of any laser system." The law also authorizes the Department to investigate and inspect all laser systems in the State for the purpose of studying and evaluating the potential hazard to the health of the people of this State caused by the use and operation of laser systems.

In accordance with the responsibilities vested in the Department of Public Health under the Laser System Registration Law the duties for administration of this Act were placed in the Division of Sanitary Engineering, Bureau of Radiological Health. Personnel from the Bureau of Radiological Health made field visits to most all of the laser installations in the State to explore the uses, applications, and potential exposures of the public to laser radiation.

Under the Laser System Registration Law, the Department of Public Health has a responsibility in controlling public health implications of laser systems much the same as it has for controlling disease organisms in public water supplies, ionizing radiation, or other segments of the environment. Because of the increasing use of laser devices there is a public awareness of the potential hazards from lasers. Lasers of the pulsed, *Q*-switched type and certain continuous-wave types can produce biological damage, with the eye as the most critical organ. As newer and expanding uses of these devices are discovered, the problems of exposure to occupational and nonoccupational persons will become apparent. Accordingly, it is important to determine in what areas the potential hazards of lasers can be controlled and to propose reasonable standards for the protection of the public without unnecessarily interfering with or hampering the judicious use and application of lasers. To this extent an inspection program was instituted to obtain factual onsite information as to the application of lasers and to determine whether any regulations for the use of these devices were feasible. At the time the inspection program was instituted, laser beam intensities were not meas-

---

[1] Mr. Courtney is a sanitary engineer in the Division of Sanitary Engineering, Bureau of Radiological Health, Department of Public Health, Springfield, Ill.

[2] Chapter 111½, paragraphs 701 through 708, Revised Statutes 1967, approved August 11, 1967.

ured because there was no suitable survey instrument available. This left certain decisions and impressions up to the judgment of the investigator. While the objectivity of this approach can be questioned, it was the only avenue open to us at the time of the inspection program.

Our survey data have shown that, with one exception, there were no flagrant violations of good "common sense" laser safety. An optometrist was shining the beam of a 1.0 milliwatt helium-neon continuous-wave laser into his patients' eyes for periods of 15 seconds. After our discovery of this practice, the optometrist was restrained from the procedure by the Optometrist Licensing Agency. The use of lasers in high schools and colleges for student instruction was generally observed to be under the supervision of the teacher when the devices were activated. In most instances the laser was locked up in a cabinet or room when not in use to prevent access by unauthorized persons. All of the lasers used in high schools and colleges were of the continuous-wave helium–neon type with outputs on the order of 1.0 milliwatt power maximum. In research and industrial applications the laser systems were used by professional research-scientist personnel.

Most lasers are costly and are not likely to fall into the hands of irresponsible people. Only a few lasers were found in industrial production. These devices were used to align machinery and in tunneling operations.

The administrative practices have been essentially the same as those used in administering the Radiation Installation Registration Law since its passage in 1957. Registration is made as easy as possible for the registrant by requiring him to furnish only such information as type of lasing media, manufacturer, power characteristics, wavelength, pulsed or continuous wave, and use. Any additional specific information needed to evaluate the health and safety hazards is obtained during the physical survey. Our attitude in administering this law is to assist the user and encourage the judicious application of lasers in industry and research without hindrance, while at the same time pointing out any immediate threat to safety or health and providing advice for the abatement of these hazards.

Dr. Wellington Moore, Jr. states in the summary of a recent publication (*1*):

"Concern over the hazards of exposure to laser radiation has resulted in the establishment of guidelines for human exposure by several agencies. Owing to the incompleteness of knowledge concerning biological effects, *particularly long-term ones*, it is not possible to set firm protection standards at this time. Current guides are based upon the minimum dose required to produce a visible lesion. These threshold values may vary depending upon the criteria by which they are measured. For the eye, threshold damage has been determined by such varying means as ophthalmoscopy, light microscopic histology, histochemical study, and electroretinography.

Very little is known about the potential cumulative effects produced by repeated subthreshold exposures either to the eye or skin. Current data in this area are not sufficient to provide information concerning the possibility of cumulative effects from repeated exposures. There appears to be some conflict over the significance of repeated subthreshold exposures in the production of damage.

Occupational hazards incidental to the use of lasers must be reduced to the very minimum. In addition to beam exposure, other potential hazards include contact with liquid nitrogen or other substances such as coolants, electrical shock, exposures to gases such as ozone, and explosions at capacitor banks, optical pump systems, and target area. A complete safety program is necessary to protect the operating personnel and other persons present at laser installations."

There is apparently little evidence of the long term or cumulative effects on the biological systems of laser radiation. For this reason, it is virtually impossible to set maximum permissible limits with any degree of assurance.

Procedure

The survey procedure was generally patterned after survey material prepared by the Bureau of Occupational Safety and Health, Consumer Protection and Environmental Health Service, Environmental Control Administration, U.S. Public Health Service. This information was used to establish a survey protocol for program planning in this State. The main goal of this survey technique was to attempt to define the potential health hazards created by the rapidly expanding application of lasers in industry and educational institutions, in a form comparable with national

occupational health survey procedures. It was felt that an evaluation of this type was necessary to assess the potential exposure of workers and the public along with present protective measures afforded, before any attempt at standards or regulations is instituted. Only after survey material of this type has been evaluated and the potential hazards from lasers defined can we determine whether present operating procedures and controls are adequate to protect the public health and safety.

While this survey protocol was designed primarily to study the health hazards from laser beams, the survey also considered chemical, electrical, or other environmental factors which might have deleterious effects on the persons in the environs of laser systems.

The first part of the survey was an interview with the appropriate management representative. During this interview, information was obtained relative to the services or product, personnel involved in laser operations, and type of medical program, such as extent of pre-employment, periodical and terminal medical examinations with emphasis on ophthalmological examinations. The safety program was reviewed with observations noted as to the safety director's knowledge or understanding of laser hazards.

The second part of the survey was a walk-through or visual observation of all areas in which laser systems were used. Data were verified regarding the type of laser, manufacturer, model, beam characteristics, output energy, wavelength, and application. Also noted were safety considerations such as warning signs, access control to laser areas, interlocks on entrances, reflectivity of room surfaces, illumination, and eye protective equipment. In high-energy laser areas, observations were made to determine what toxic materials were used or stored in the area, whether toxic target materials were vaporized during laser operations, and whether management was aware of the toxicity of these pollutants. If, during a survey it was found that an immediate potential hazard existed, the investigator provided technical assistance to management in pointing out the potential severity of such hazard and offered suggestions for abatement of the hazard. At the same time he advised management that the Department had no control powers and the recommendations were merely given in the spirit of being helpful in the abatement of such health or safety problems. The visual or walk-through type of survey admittedly does not yield information in adequate detail to determine complete control of all hazards under all the variations of use. These data, however, can be useful for categorizing degrees of hazards for a later, more thorough investigation of the problem to reduce the risk or hazard to public health. In this survey program, we very carefully guarded against projecting any attitude of proposing unrealistic safety measures at the expense of hindrance in the judicious use of lasers.

The Illinois Department of Public Health prepared forms and accepted registrations for laser systems prior to January 1, 1968 as required by the law. To date there have been 57 installations with a total of 184 laser systems registered with the Department. One installation, for example, uses some 70 laser systems in the confines of the institution.

The facilities registrating lasers are distributed by category as follows:

High schools	10
Universities and colleges	15
Industries	28
Optometrists	1
Laser manufacturers	3

Of the 57 registered facilities, 48 have been inspected. In the group of 48 inspections, there were 28 industries, 11 colleges and universities, 3 high schools, 1 research organization, 3 manufacturers and distributors, and 2 others, as shown in table 1.

Table 1. Laser systems surveyed by category and lasing medium, January 1968–March 1969

Laser type	Industries	Colleges and universities	High schools	Research	Manufacturers and distributors	Other	Total
Helium-neon	38	38	3	9	22	1	111
Ruby	5	5		1		1	12
Carbon dioxide	1	1					2
Argon	1	1					2
Neodymium	2	1					3
Gallium - arsenic	2						2
Total lasers surveyed	49	46	3	10	22	2	132
Total registrants surveyed	28	11	3	1	3	2	48

The inspections tabulated "as others" were 1 optometrist, and 1 State medical institution. Of the 111 helium-neon gas lasers inspected, 14 were rated above 3.0 milliwatts. Two of the 14 were rated at 50.0 milliwatts (the maximum output in the group).

The ruby lasers, all of which were pulsed, ranged in intensities from 1.0 joule to 100 megawatts. All of the installations having ruby-pulsed lasers provided eye protective devices manufactured by two leading firms supplying eye protective equipment for wave lengths of 6,000 to 8,000 Å

The following are descriptions of some of the applications of lasers by the industrial users.

Machine alignment A helium-neon laser of the continuous-wave type at 6,328 Å and 15 microwatts power is used to traverse the bed of a computerized milling machine. The laser is installed on one end of the milling-machine bed and the beam is transmitted to a reflecting prism at the opposite end of the bed. The beam is then reflected back to the photoelectric cell adjacent to the laser head. Analysis of the beam by a computer determines horizontal travel and depth of cut of the milling head. The depth of cut can be determined to a tolerance of 17×10^{-6} inch. Once programmed, the machine performs cutting, drilling, and tapping operations automatically as commanded by the computer. The entire laser unit and photocell is contained in a steel housing and is permanently mounted on the milling machine. The beam traverses the machine cutting bed 8 inches above the base and is not subject to direct viewing by passersby or machine operators. The machine is in the experimental stages and if proven successful, will be sold to automotive and other large machine manufacturers.

Another plant attempted unsuccessfully to incorporate a 1.0 milliwatt laser in a device for alignment of 120-foot-long milling machine beds to a tolerance of 0.0001 inch. Because of wave interferences, vibrations, and air movements, the use of this device was discontinued.

Earth moving machinery A research program for controlling the height of cut of a motor grader in cut-and-fill operations at an industrial plant uses a laser mounted vertically in a 5-inch-diameter steel tube in the center of a tripod. The laser beam is directed upward, striking a pentaprism mirror mounted in a turret at the top of the steel tube approximately 8 feet above grade. The motorized turret revolves at 300 rpm and allows the beam to sweep an area of 360° to a distance of 500 feet. The motor grader is equipped with a series of solar cells mounted on an antenna placed well above the head of the operator. The beam signal, then received at a specific height on the antenna, is amplified, and recorded on instruments which are calibrated to determine the depth of cut or height of fill to be made by the machine from the preestablished reference point. The grader can be operated up to distances of 500 feet from the laser sending station. The laser is a 1.0 milliwatt, helium-neon continuous wave device having a 2-millimeter beam diameter at the aperture and 0.4 milliradian divergence. The rotating mirror turret is electrically connected in series with the laser generator in a manner such that if the turret stops rotating, the laser is inactivated. Because of the rotational characteristics of the pentaprism mirror, and considering a laser sending power level of 1.0 milliwatt, the probability of this application creating a safety hazard to observers appears small if operated as designed.

Another operation at this plant employs a 1.0 milliwatt, helium-neon continuous-wave laser to determine the roundness of an orifice for a fuel-injection nozzle and to measure flatness of steel surfaces in research projects.

Public relations One telephone company uses a laser for demonstrating to public groups the sound carrying capability of laser beams. The laser is a 5-milliwatt, helium neon, continuous-wave portable device. A record player is connected to the laser head and sound is transmitted by the beam to a photoelectric cell—amplifier speaker arrangement. When the beam is intercepted, sound at the speaker is interrupted, demonstrating that the sound is transmitted on the laser beam. Audiences are reminded not to look into the direct beam. This system is distributed through 11 of the company's operating branches throughout the country.

Tunneling The laser beam is used as a navigational aiming device in tunnel construction. The laser is a 5.0 milliwatt, helium-neon continuous-wave device. The laser head is mounted on the tunnel wall and the beam is focused on a target mounted on the boring machine some distance forward and above the head of the operator. The positioned laser beam strikes a mark on the target and by observing the light spot from the laser,

the operator can continuously maintain the correct vertical and horizontal direction of the boring face for distances up to 400 feet without resetting the laser. In this instance, the "mole" was drilling a hole 14 feet in diameter.

No safety goggles for lasers are provided for the operator as management feels there is no danger to the eye because of the low-power output of the laser. In addition, goggles for the wavelength of a helium-neon laser would reduce visibility and expose the operator to other hazards in the environment.

Laser manufacturing One company which was inspected manufactures the complete laser system including the glass-lasing tube, mirror system, and electrical components. At the time of inspection, this company manufactured only the helium-neon continuous-wave lasers in the 1.0 to 2.5-milliwatt range, at a production capacity of 18 systems per day. Because of the low energy characteristics of the lasers manufactured in this plant, no special eye protective devices are provided for the employees.

There is also a company engaged in the manufacture of a sewer line and grade alignment system incorporating a 1.3 milliwatt, helium neon, continuous-wave laser as a light source. This is a small operation with an output of 3 to 4 units per month and employing 3 technicians at the present time. The device has a warning sign "Laser Beam—No Direct Viewing."

Spectroscopic application A Q-switched, 1.0 joule, neodymium-doped glass laser is used in conjunction with a microprobe spectroscope as a heat source for vaporizing metal samples and as a partial light source for spectroscopic analysis of these metals. The metals used in electrical components are copper, silver, gold, cadmium, lead, mercury, and so forth. The sample is placed on the microscope stage and a small area is vaporized by the laser beam. The binocular microscope is used for alignment of the sample and for viewing the results of the destructive analysis of the sample. The room in which this testing was being done was rather small, was crowded with laboratory apparatus and had no mechanical ventilation. Some of the metals (especially lead, cadmium, and mercury) when vaporized could create a potential health hazard by building up a residue of fumes and particulates in the room. A small local exhaust ventilation system was provided for ventilating the carbon arc (an integral part of the spectroscope). It was recommended that a small local exhaust hood be provided around the periphery of the sample vaporizing area and connected to the existing exhaust system for the carbon arc.

Summary and conclusions

1. The Laser System Registration Law with its survey requirements has provided the Illinois Department of Public Health with the authority to evaluate the public health implications of lasers and other areas of radiation in the electromagnetic spectrum.

2. By continuing the registration and inspection of lasers, the Department can provide a reservoir of information in this new field of radiation. The Department will serve as a collection and dissemination agency from which the public and interested groups may obtain information on public health problems that may evolve from the use of these devices.

3. Until more specific details are available on the subthreshold and long-term biological effects due to lower energy laser radiation exposures, there should be no exemption from the registration requirements.

4. There is a need to continue the inspection program to keep abreast of new developments as they arise in the laser field. These inspections should be conducted on a priority basis; however, they should not be based only on the severity of the potential hazard to individuals in-plant, but also on the degree of epidemiological impact that laser radiation might have on the public when used in an offsite outdoor environment. The suggested priorities are as follows:

a. high intensity laser systems applied in industrial processes,

b. lower intensity laser systems used in outdoor processes that would potentially expose the general public, such as surveyor and sewer alignment instruments, traffic control, and so forth,

c. lasers used in research institutions, and

d. lasers used as high school and college teaching instruments.

5. Because of the paucity of information on subthreshold and long-term effects of laser radiation on the biological system it would be premature, in our opinion, to establish standards for

control of laser users at this time. The laser problem might best be handled on the basis of a continued educational approach and provisions for assistance in matters of safe laser operation upon request from users. Furthermore, in view of the provisions of Public Law 90–602 entitled "Radiation Control for Health and Safety Act of 1968," Sec. 360f, it would appear that in the near future Federal Standards developed under this law would supersede any State regulations which were not completely compatible with these standards.

6. During our inspections, we impressed upon the registrants that the purpose of the law was merely to give the Department the authority to locate laser systems and to study the potential or real health hazards arising out of the use of lasers and assured them that there were no provisions for controls of such use. It was our philosophy that indiscriminate use of such a law could hamper the judicious use of lasers.

7. At the time of this report, the only accident reported to this Department was one case of electrical shock in which there was no serious injury or loss of work time for the employee.

REFERENCE

(1) MOORE, WELLINGTON, JR. Biological aspects of laser radiation, a review of hazards. Report, Research Branch, National Center for Radiological Health, Rockville, Md. 20852 (Reprinted January 1968).

A Comparison of the Cesium-137 Content of Milk and People From 19 Dairy Farms in Utah[1]

R. D. Lloyd, C. W. Mays, R. C. Pendleton, and *D. O. Clark*[2]

Measured cesium-137 concentration (pCi $^{137}Cs/g$ K) in milk from 19 Utah dairy farms and in residents of those farms, have been compared for the period 1962 through 1966. During the time when cesium-137 levels were increasing (1962–1964), the cesium-137 to potassium ratios in people were similar to the ratios in milk produced by the dairy farm on which they resided. During the time when cesium-137 levels were decreasing (1964–1966) the ratios in people averaged about 2.5 to 4 times higher than the milk. Differences in biological half-times of cesium for men, women, and children are reflected in their respective body concentrations of cesium-137. This comparison suggests that measured cesium-137 to potassium ratios of milk might be used to estimate the cesium-137 concentration of a population with similar dietary habits during a corresponding time period without considering such factors as milk intake or the consumption of non-milk foods. Preliminary analysis of the relationship between milk levels and body cesium-137 concentration of individual subjects indicates that milk cesium-137 data can be used with appropriate human biological half-times to estimate the shape of human $^{137}Cs/K$ curves for the same time period.

As part of a study of the accumulation of cesium-137 under different ecological conditions, body burdens of cesium-137 and potassium in residents of a number of Utah dairy farms (figure 1), (*1–2*) were determined periodically from 1962 to 1966 by total body counting. These measurements provided an opportunity to compare cesium-137 levels in this group of people with cesium-137 levels in milk from the dairy farms on which they resided. Milk was collected monthly or semimonthly from each of these farms and was analyzed for cesium-137 and potassium (determined from potassium-40 content) by gamma-ray spectroscopy. Methods used to determine the levels of gamma-ray emitters in milk (*2–3*), and in humans (*2, 4, 5*) have been described. Our human counting techniques have been evaluated in references (*6*) and (*7*).[3]

Results of milk and human counting are plotted in figures 2 through 20 for the 19 farms for which we had at least 2 years of human data and concurrent milk collections. In making this comparison of people and milk, cesium-to-potassium ratios

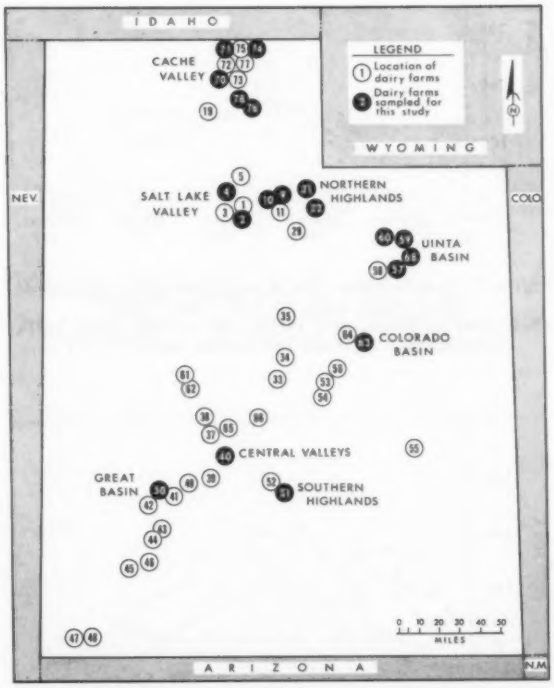

Figure 1. Sampling locations of dairy farms

(pCi $^{137}Cs/g$ K) were employed. This allowed the milk and human data to be expressed in the same units. In addition, milk data and human data were of about the same magnitude when these units were employed. Ratios of cesium-137 to

[1] Supported by a U.S. Public Health Service, Bureau of Radiological Health Grant RH-30.

[2] Mr. Lloyd and Dr. Mays are members of the Department of Anatomy and Dr. Pendleton is a member of the Department of Radiological Health, University of Utah, Salt Lake City, Utah. Mr. Clark was with the Department of Anatomy, University of Utah and is presently at the Duke University Medical Center, Durham, N.C.

[3] Participating laboratory number 15.

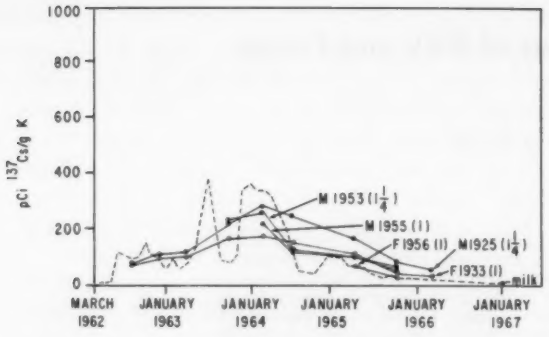

Figure 2. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #2, Salt Lake Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

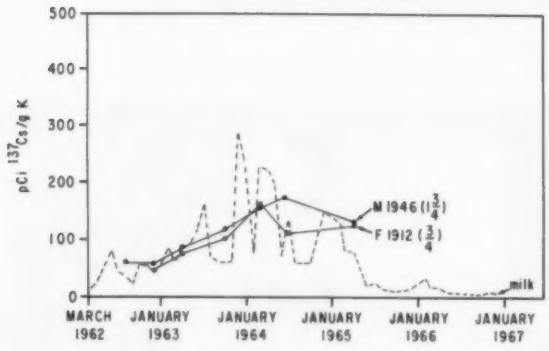

Figure 3. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #4, Salt Lake Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

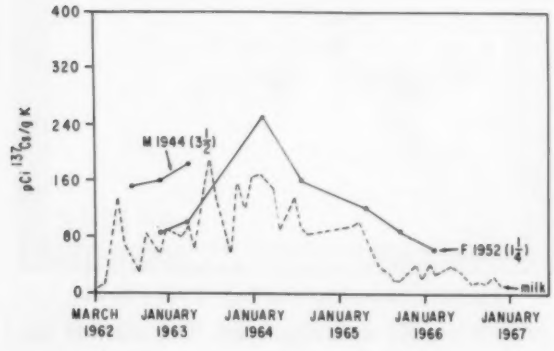

Figure 4. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #9, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

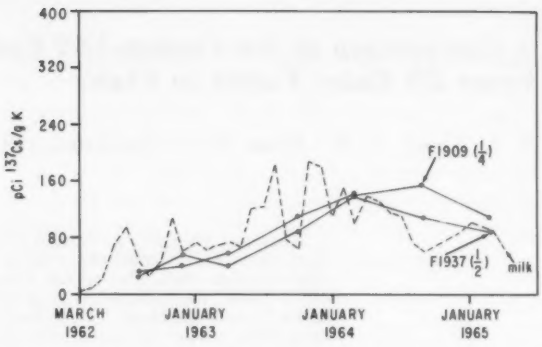

Figure 5. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #10, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

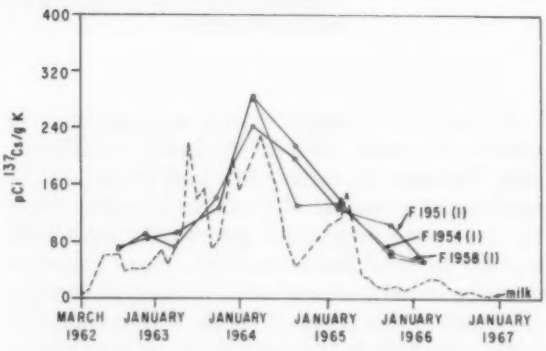

Figure 6. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #31, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

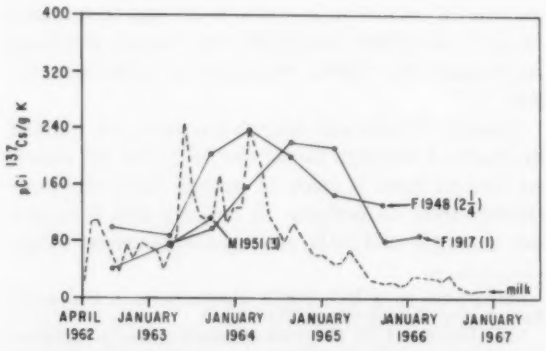

Figure 7. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #32, Northern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

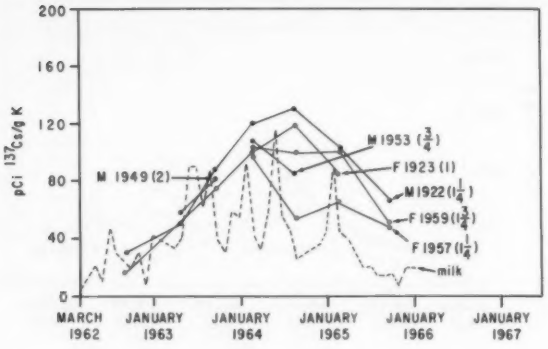

Figure 8. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #40, Central Valleys (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

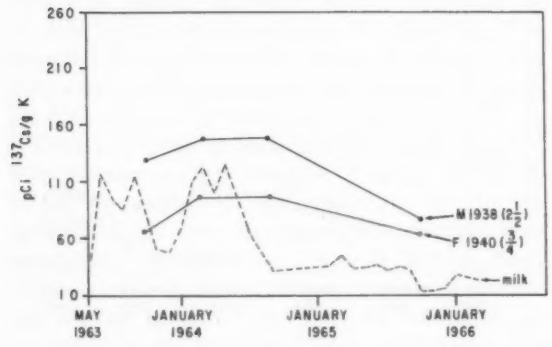

Figure 9. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #50, Great Basin (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

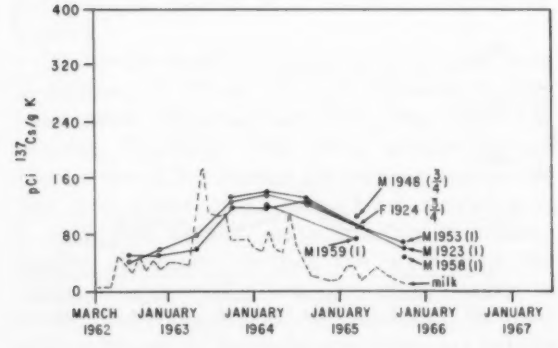

Figure 10. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #51, Southern Highlands (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

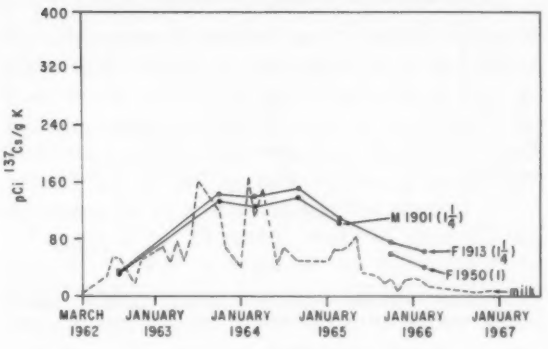

Figure 11. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #57, Uinta Basin (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

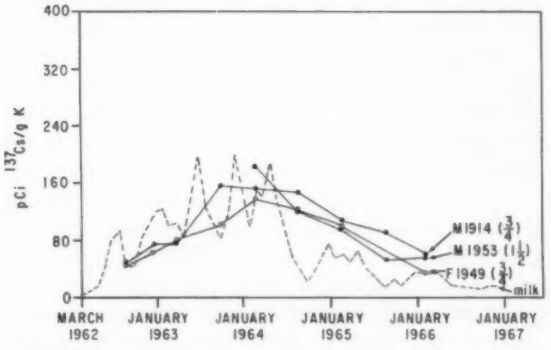

Figure 12. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #60, Uinta Basin (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

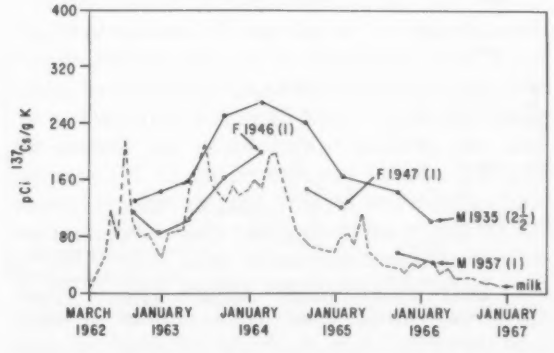

Figure 13. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #60, Uinta Basin (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

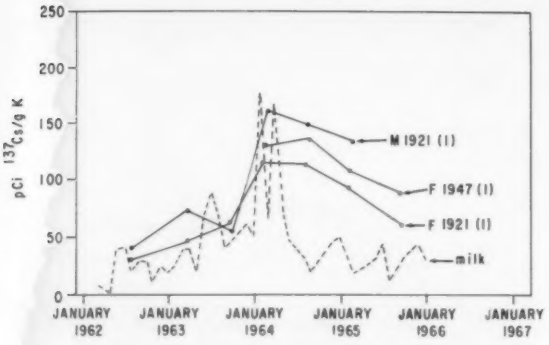

Figure 14. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #63, Colorado Basin (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

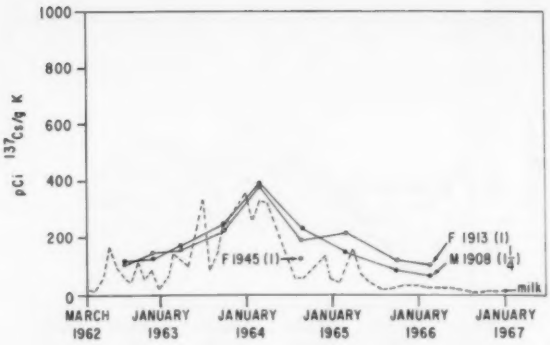

Figure 17. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #71, Cache Valley (Sex, year at birth, and estimated average daily milk consumption in liters shown for each subject)

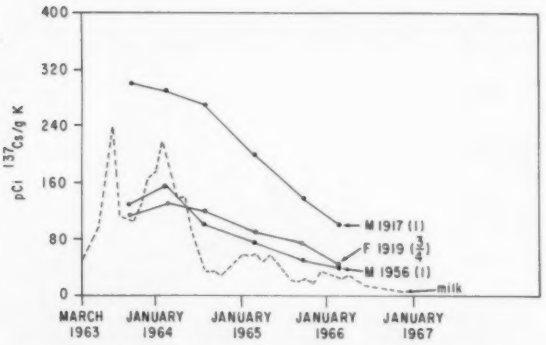

Figure 15. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #68, Uinta Basin (Sex, year at birth, and estimated average daily milk consumption in liters shown for each subject)

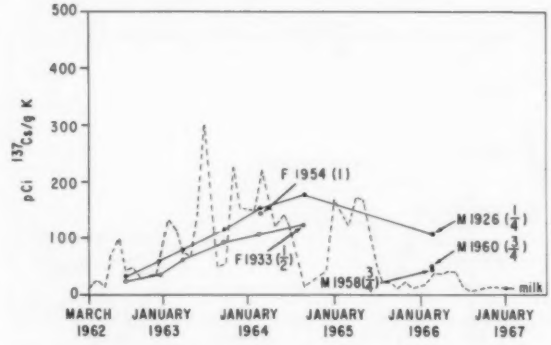

Figure 18. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #74, Cache Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

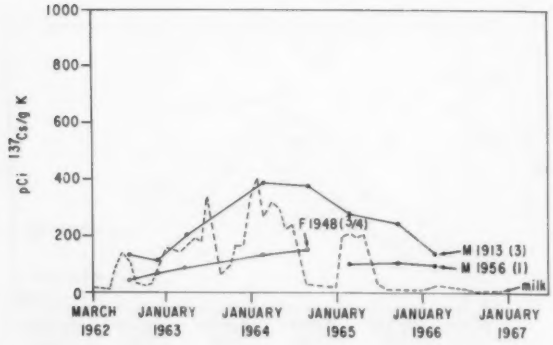

Figure 16. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #70, Cache Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

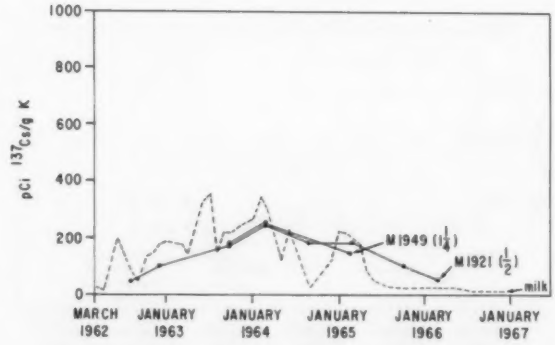

Figure 19. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #76, Cache Valley (Sex, year at birth, and estimated average daily milk consumption in liters shown for each subject)

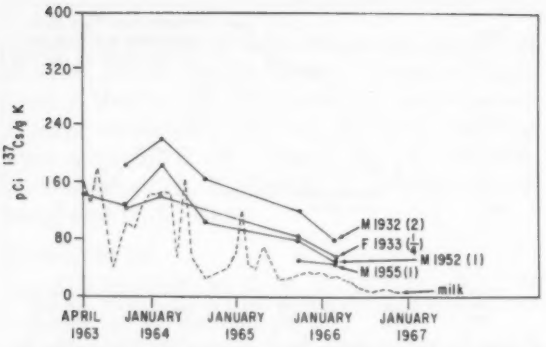

Figure 20. Comparative ^{137}Cs/K ratios for milk and people from dairy farm #78, Cache Valley (Sex, year of birth, and estimated average daily milk consumption in liters shown for each subject)

potassium within a family were much more uniform than cesium-137 body burdens. An example of this relationship is shown in figure 6. The cesium-137 to potassium ratios of these three sisters were similar although their cesium-137 body burdens differed by factors of 2 to 3.

Concentrations of cesium-137 in milk in pCi/liter for any month may be obtained by multiplying the cesium-137 to potassium ratio by the approximately constant average potassium concentration measured for the milk in this study (1.59 ± 0.18 g K/liter).[4] Concentrations of cesium-137 in the human body may be estimated by multiplying the cesium-137 to potassium ratios by the average potassium concentration of humans (*8*), about 2.10 ± 0.23 g K/kg for males, and 1.78 ± 0.26 g K/kg for females.[4] Since the healthy human is in potassium equilibrium, his potassium content is not controlled by his potassium intake but changes mainly as a result of growth or wasting.

Month-by-month variations in milk values seen in figures 2 to 20 are real and represent periods when cattle consumed feed of varying cesium-137 content. Typically, Utah dairy farmers harvest three crops of hay during the growing season; the first crop, grown in the spring when rainfall is at a maximum usually contains a higher concentration of cesium-137 than the subsequent two crops. Whenever this first crop of hay is fed to cattle, the concentration of cesium-137 in their milk increases. It decreases when they are fed the material less rich in cesium-137. Local fallout can alter this general pattern, and a unique series of peaks and valleys in the milk data can occur when cattle are shifted from one type of feed to another, such as from dry hay to grazing or to freshly-cut alfalfa. First crop hay, held for several months before feeding, can produce a cesium-137 maximum in milk even during the winter.

Figures 2 to 20 reveal that, in general, the ^{137}Cs/K in milk is reflected in the ^{137}Cs/K in people who consume that milk. Month-by-month fine structure in the milk curve, however, is not evident in the curves representing humans. Several factors are responsible for this, among which are:

1. human subjects were not measured as often as milk, so some fine structure was undoubtedly missed. This is suggested by the *decreasing* cesium-137 body burdens following the summer 1962 peak in milk for dairy farm stations 4, 32, 51, 60, and 70 (figures 3, 7, 10, 13, and 16) in the face of a generally *increasing* cesium-137 content in food;

2. milk was not the only source of cesium-137 (or potassium) in the diets of these subjects. But for at least some of these families, their milk was the major source of cesium-137 during at least the early part of this study (*9*);

3. the concentration of cesium-137 in milk is determined by the consumption of cesium-137 by the cow when the milk is being produced, so changes in daily feeding are rapidly reflected by changing cesium-137 levels in milk. The human, however, because of his relatively longer retention time for cesium-137, is an integrator of previous and present intake, and his total cesium-137 body burden does not change rapidly when his intake is sharply diminished (*10*).

Human body burdens depend not only on the intake of cesium-137, but also on the characteristic cesium metabolism for an individual (*11*). Adult males have a long equivalent biological half-time for cesium (105 days $\pm$ 25 days),[4] while the values for women (84 $\pm$ 28 days),[4] children and adolescents (57 $\pm$ 20 days),[4] and infants (19 $\pm$ 8 days),[4] are shorter (*10*). Women and children tend to have lower body concentrations of cesium-137 (^{137}Cs/K) than men consuming a similar diet because of their shorter equivalent biological half-times for cesium. This trend can be seen in our data on farms for which an entire family has been measured (figure 20).

A striking observation that one can make from figures 2 to 20 is that the cesium-137 to potassium

[4] One-standard deviation.

ratios of the people in most cases were similar to the cesium-137 to potassium ratios in their dietary milk during the time when their cesium-137 contents were increasing. The people generally had a higher cesium-137 to potassium ratio than milk during the time when their cesium-137 contents were decreasing.

We have shown in other studies (*11*) that for children and adults, body $^{137}Cs/K$ is about 2 to 4 times higher than the $^{137}Cs/K$ in their total dietary intake. During the increasing phase of this study, the ratios in people and milk were similar; this observation coincides with the expectation that food other than milk may have been the major source of potassium for these people but that their milk may have been a major source of cesium-137. With rapidly diminishing levels of cesium-137 in milk, human body burdens decrease less rapidly, not only because of the long cesium retention times in humans, but also because of the intake of processed foods (usually produced at earlier times when cesium-137 levels may have been higher) thus altering the relative contribution of cesium-137 from milk and non-milk foods in the diet. The $^{137}Cs/K$ in people averaged about 2.5 to 4 times that in their milk during the decreasing phase. Values for men were the highest, values for children were the lowest, and values for women were intermediate. This is a consequence of the differing cesium half-times for these groups.

Because of the dependence of body burden on cesium half-time, it is appropriate to relate the human data and milk data by a function that includes the cesium half-time of the individual as a factor. Assuming that a mildly perturbed, steady-state system can be treated as a first order, one compartment system, a computer program[5] was written which estimated the cesium half-time of a subject based on his serially-measured body burdens and the cesium-137 levels in the milk produced on the farm on which he resided. Figure 21 shows the shape of the month-by-month predicted body cesium-137 to potassium ratios calculated for one of these dairy farmers using the biological half-time obtained by this program and the assumption that the rate of cesium-137 intake is proportional to the milk cesium-137 content. The plotted points represent actual

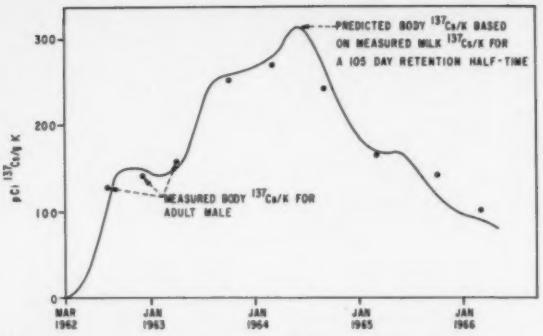

Figure 21. Comparison of measured $^{137}Cs/K$ ratios for male adult [(M 1935—2½) in figure 13] with predicted values based on a 105 day cesium half-time (calculated from milk and body concentration data)

measurements. This farmer's calculated half-time of 105 days agrees well with the average cesium half-time measured for adult males of 105 ± 25 days (*10*). Similar data for a female child are shown in figure 22. Her calculated half-time of 60 days agrees well with the average value measured for children of 57 ± 20 days (*10*). The agreement between measured and predicted body burdens for the two subjects for whom this analysis has been made is surprisingly good.

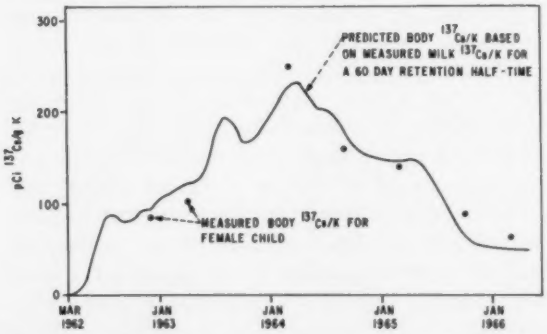

Figure 22. Comparison of measured $^{137}Cs/K$ ratios for female child [(F 1952—1¼) in figure 4] with predicted values based on a 60 day cesium half-time (calculated from milk and body concentration data)

An expanded analysis of the relationship between the cesium-137 content of milk and the cesium-137 content of humans consuming that milk via a transfer function that includes the individual cesium half-time and the individual milk consumption value as factors is planned for a future report.

Acknowledgements

The cooperation of the farm families that participated in this study was essential and is acknowl-

[5] Details of the assumptions, concepts, and mathematics used for this computer program may be obtained from the authors upon request.

edged with thanks as is the continuous support of the U.S. Public Health Service, Bureau of Radiological Health (RH–30) during the entire period. Human whole-body counting and milk counting were done by B. W. Church, W. W. Wagner, R. L. Aamodt, A. B. Tueller, C. McBride Woodbury, and W. C. Knott.

REFERENCES

(*1*) PENDLETON, R. C., R. D. LLOYD, and C. W. MAYS. Iodine-131 in Utah during July and August 1962. Science 141:640–642 (1963).

(*2*) PENDLETON, R. C., C. W. MAYS, R. D. LLOYD, and A. L. BROOKS. Differential accumulation of iodine-131 from local fallout in people and milk. Health Physics 9:1253–1262 (1963).

(*3*) CHURCH, B. W., R. D. LLOYD, R. C. PENDLETON, and C. W. MAYS. Evidence for radioruthenium in milk. Nature 207:775 (1965).

(*4*) LLOYD, R. D. Human total-body counter calibration. Res Radiobiol COO–119–229:186–198 (1964).

(*5*) INTERNATIONAL ATOMIC ENERGY AGENCY. Directory of Whole Body Radioactivity Monitors. International Atomic Energy Agency, Vienna 411 (1964).

(*6*) MALETSKOS, C. J., P. N. DEAN, S. A. LOUGH, and C. E. MILLER. Intercomparison of reliability of body ^{137}Cs measurements on human beings, TID–23740 (1967).

(*7*) MALETSKOS, C. J., P. N. DEAN, S. A. LOUGH, and C. E. MILLER. Intercomparison of the reliability of body cesium-137 measurements in human beings. Health Physics 13:1307–1320 (1967).

(*8*) WAGNER, W. W., C. W. MAYS, R. D. LLOYD, R. C. PENDLETON, and W. S. ZUNDEL. Potassium studies in humans. Res Radiobiol COO–119–235:107–136 (1966).

(*9*) BROOKS, A. L. Comparative Radiation Ecology of Six Utah Dairy Farms. Thesis, University of Utah (1963).

(*10*) LLOYD, R. D., W. S. ZUNDEL, C. W. MAYS, W. W. WAGNER, R. C. PENDLETON, and R. L. AAMODT. Cesium-137 half-times in normal, in dystrophic, and in pregnant humans. Res Radiobiol COO–119–234:297–317 (1966).

(*11*) PENDLETON, R. C., C. W. MAYS, R. D. LLOYD, and B. W. CHURCH. A trophic level effect on cesium-137 concentration. Health Physics 11:1503–1510 (1965).

SECTION I. MILK AND FOOD

Milk Surveillance, June 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be leased to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health, Environmental Control Administration, and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

Figure 1. Milk sampling networks in the Western Hemisphere

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in December 1968, with 37 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131 and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In general, the results for iodine-131 and cesium-137 are adequate but the results for strontium-89 and strontium-90 need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8*, *9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age: cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels following an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

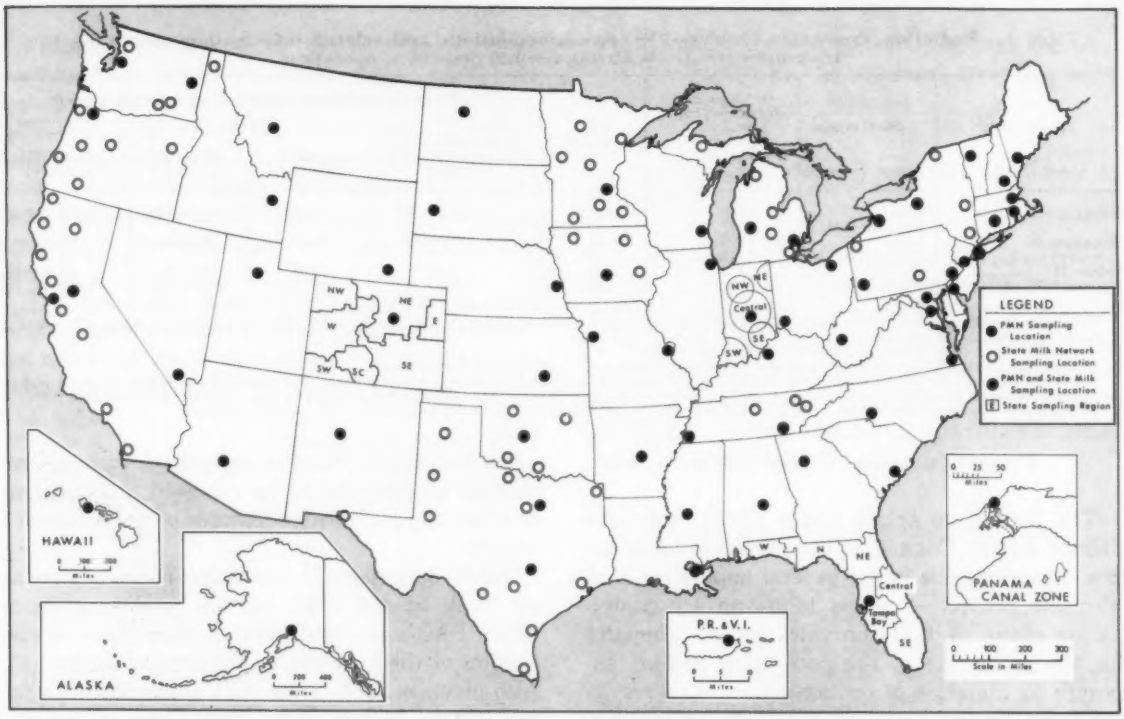

Figure 2. State and PMN milk sampling locations in the United States

maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for June 1969 and the 12-month period, July 1968 to June 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for June 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 was detected.

Table 3. Concentration of radionuclides in milk for June 1969 and 12-month period, July 1968 through June 1969

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	7	6	0 (3)	0	3 (3)	11
Alaska:	Palmer[c]	P	4	6	0	0	0	12
Ariz:	Phoenix[c]	P	3	1	0 (4)	0	0 (4)	1
Ark:	Little Rock[c]	P	20	20	0 (4)	0	15 (4)	18
Calif:	Sacramento[c]	P	4	2	0 (5)	0	0 (5)	1
	San Francisco[c]	P	2	2	0 (4)	0	0 (4)	2
	Del Norte	P	21	20	0	0	21	21
	Fresno	P	0	0	0	0	0	3
	Humboldt	P	5	0	0	0	12	11
	Los Angeles	P	0	1	0	0	0	4
	Mendocino	P	3	3	0	0	0	3
	Sacramento	P	3	3	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	5
	Shasta	P	3	3	0	0	0	5
	Sonoma	P	3	2	0	0	0	3
Colo:	Denver[c]	P	5	5	0 (3)	0	4 (3)	4
	West	R	(d)		NS	(e)	NS	(e)
	Northeast	R	(d)		NS	(e)	NS	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South Central	R	(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	8	9	0 (4)	0	13 (4)	12
	Central	P	8	7	0 (4)	0	10 (4)	10
Del:	Wilmington[c]	P	NA		0 (2)	0	7 (2)	7
D.C.:	Washington[c]	P	6	8	0 (3)	0	6 (3)	4
Fla:	Tampa[c]	P	4	8	0 (3)	0	61 (3)	62
	West	R	11	11	0	11	18	24
	North	R	22	14	0	0	31	36
	Northeast	R	7	9	0	0	76	72
	Central	R	NA	8	0	1	72	75
	Tampa Bay area	R	9	8	0	0	50	63
	Southeast	R	NA	9	0	0	126	111
Ga:	Atlanta[c]	P	10	12	0 (3)	0	21 (3)	19
Hawaii:	Honolulu[c]	P	3	4	0 (4)	0	0 (4)	1
Idaho:	Idaho Falls[c]	P	5	5	0 (5)	0	5 (5)	8
Ill:	Chicago[c]	P	7	8	0 (5)	0	11 (5)	11
Ind:	Indianapolis[c]	P	9	8	0 (5)	0	4 (5)	6
	Northeast	P	13	10	0	0	0	10
	Southeast	P	7	9	0	0	10	10
	Central	P	10	9	0	0	10	11
	Southwest	P	10	8	0	0	5	11
	Northwest	P	12	11	0	0	20	12
Iowa:	Des Moines[c]	P	0	5	0 (4)	0	3 (4)	3
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	7	0 (5)	0	3 (5)	3
Ky:	Louisville[c]	P	10	11	0 (3)	0	10 (3)	7
La:	New Orleans[c]	P	16	18	0 (3)	0	21 (3)	22
Maine:	Portland[c]	P	11	12	0	1	26	25
Md:	Baltimore[c]	P	9	9	0 (5)	0	4 (5)	7
Mass:	Boston[c]	P	11	11	0 (3)	0	19 (3)	22
Mich:	Detroit[c]	P	8	9	0 (5)	0	7 (5)	10
	Grand Rapids[c]	P	13	10	0 (5)	0	9 (5)	14
	Bay City	P	NA	5	0	0	16	11
	Charlevoix	P	NA	9	(e)	(e)	18 (5)	13
	Detroit	P	NA	5	(e)	(e)	3 (5)	4
	Grand Rapids	P	NA	6	(e)	(e)	13 (5)	10
	Lansing	P	NA	5	(e)	(e)	11 (3)	5
	Marquette	P	NA	9	(e)	(e)	27 (2)	29
	Monroe	P	NA	3	(e)	1	0 (2)	1
	South Haven	P	NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	14	12	0 (4)	0	9 (4)	13
	Bemidji	P	16	16	0	0	27	22
	Mankato	P	10	7	0	0	8	0
	Rochester	P	7	8	0	0	13	0
	Duluth	P	20	20	0	0	24	27
	Worthington	P	10	7	0	0	0	0
	Minneapolis	P	14	13	0	0	11	13
	Fergus Falls	P	11	10	0	0	11	0
	Little Falls	P	10	10	0	0	14	16
Miss:	Jackson[c]	P	13	15	0 (4)	1	15 (4)	16
Mo:	Kansas City[c]	P	9	7	0 (4)	0	3 (4)	2
	St. Louis[c]	P	9	9	0 (4)	0	3 (4)	5
Mont:	Helena[c]	P	6	5	0 (3)	0	7 (3)	8
Nebr:	Omaha[c]	P	6	6	0 (3)	0	1 (3)	3
Nev:	Las Vegas[c]	P	0	1	0 (4)	0	0 (4)	1
N.H.:	Manchester[c]	P	11	11	0 (4)	0	21 (4)	30
N.J.:	Trenton[c]	P	10	9	0 (4)	0	6 (4)	9
N. Mex:	Albuquerque[c]	P	2	2	0 (5)	0	0 (5)	1

See footnotes at end of table.

Table 3. Concentration of radionuclide in milk for June 1969 and 12-month period, July 1968 through June 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo [c]	P	8	7	0 (4)	0	10 (4)	10
	New York City [c]	P	12	11	0 (5)	0	14 (5)	14
	Syracuse [c]	P	7	8	0 (4)	0	8 (4)	8
	Albany	P	8	8	0 (5)	0	(e) (5)	(e)
	Buffalo	P	(e)	(e)	0	0	(e)	(e)
	Massena	P	11	11	0 (3)	0	26 (3)	(e)
	Newburg	P	(e)	11	0	0	(e)	(e)
	New York City	P	11	12	0 (4)	0	(e) (4)	(e)
	Syracuse	P	6	8	0	0	(e)	(e)
N.C:	Charlotte [c]	P	18	15	0 (4)	0	17 (4)	12
N. Dak:	Minot [c]	P	9	11	0 (5)	0	10 (5)	12
Ohio:	Cincinnati [c]	P	9	8	0 (4)	0	1 (4)	3
	Cleveland [c]	P	9	9	0 (4)	0	8 (4)	8
Okla:	Oklahoma City [c]	P	11	9	0 (4)	0	16 (4)	8
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland [c]	P	7	8	0 (4)	0	8 (4)	10
	Baker	P	NA	3	(e)	(e)	(e)	8
	Coos Bay	P	NA	8	(e)	(e)	23	15
	Eugene	P	NA	4	(e)	(e)	(e)	12
	Medford	P	NA	2	(e)	(e)	15	14
	Portland composite	P	NA	5	(e)	(e)	(e) (4)	5
	Portland local	P	NA	5	(e)	(e)	19	6
	Redmond	P	NA	2	(e)	(e)	(e)	5
	Tillamook	P	NA	8	(e)	(e)	(e)	22
Pa:	Philadelphia [c]	P	9	9	0 (4)	0	4 (4)	6
	Pittsburgh [c]	P	13	12	0 (4)	0	9 (4)	9
	Dauphin	P	7	7	NA	0	NA	19
	Erie	P	11	11	NA	0	NA	22
	Philadelphia	P	9	9	NA	0	NA	18
	Pittsburgh	P	7	11	NA	0	NA	16
R.I:	Providence [c]	P	12	10	0 (4)	0	18 (4)	18
S.C:	Charleston [c]	P	9	12	0 (3)	0	23 (3)	23
S. Dak:	Rapid City [c]	P	10	7	0 (5)	0	5 (5)	8
Tenn:	Chattanooga [c]	P	11	12	0 (4)	0	22 (4)	13
	Memphis [c]	P	10	10	0 (3)	0	4 (3)	5
	Chattanooga	P	8	11	3 (5)	0	20	16
	Clinton	P	31	14	0 (2)	0	19	17
	Knoxville	P	16	10	0 (3)	1	14	10
	Nashville	P	6	9	0 (3)	0	15	7
Tex:	Austin [c]	P	0	2	0 (2)	0	6 (2)	3
	Dallas [c]	P	8	7	0 (4)	0	14 (4)	7
	Amarillo	R	NS		NS		NS	
	Corpus Christi	R	NS		NS		NS	
	El Paso	R	NS		NS		NS	
	Fort Worth	R	NS		NS		NS	
	Harlingen	R	NS		NS		NS	
	Houston	R	NS		NS		NS	
	Lubbock	R	NS		NS		NS	
	Midland	R	NS		NS		NS	
	San Antonio	R	NS		NS		NS	
	Texarkana	R	NS		NS		NS	
	Uvalde	R	NS		NS		NS	
	Wichita Falls	R	NS		NS		NS	
Utah:	Salt Lake City [c]	P	0	5	0 (4)	0	0 (4)	9
Vt:	Burlington [c]	P	9	9	0 (4)	0	14 (4)	11
Va:	Norfolk [c]	P	9	10	0 (3)	0	3 (3)	8
Wash:	Seattle [c]	P	9	9	0 (4)	0	19 (4)	18
	Spokane [c]	P	3	6	0 (4)	0	9 (4)	7
	Benton County	R	NS	1	NS	0	NS	6
	Franklin County	R	3	1	0	0	0	0
	Sandpoint, Idaho	R	15	10	0	0	32	25
	Skagit County	R	10	6	0	0	15	11
W. Va:	Charleston [c]	P	NA	10	0 (2)	0	5 (2)	8
Wisc:	Milwaukee [c]	P	7	7	0 (4)	0	12 (4)	12
Wyo:	Laramie [c]	P	4	4	0 (4)	0	1 (4)	10
CANADA:								
Alberta:	Calgary	P	7	8	(d)		11	16
	Edmonton	P	4	7	(d)		10	17
British Columbia:	Vancouver	P	14	13	(d)		36	42
Manitoba:	Winnipeg	P	8	8	(d)		18	24
New Brunswick:	Fredericton	P	11	14	(d)		22	21
Newfoundland:	St. Johns	P	17	19	(d)		34	38
Nova Scotia:	Halifax	P	11	11	(d)		17	20
	Ft. William	P	15	16	(d)		22	32
Ontario:	Ottawa	P	10	9	(d)		11	17
	Sault Ste. Marie	P	16	15	(d)		29	33

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for June 1969 and 12-month period, July 1968 through June 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA—Continued								
Ontario:	Toronto	P	5	5	[d]		6	13
	Windsor	P	7	6	[d]		9	13
Quebec:	Montreal	P	10	8	[d]		14	19
	Quebec	P	12	11	[d]		23	27
Saskatchewan:	Regina	P	6	7	[d]		9	16
	Saskatoon	P	4	9	[d]		9	17
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	NS		NS		NS	
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	0	5	0	0	175	100
Venesuela:	Caracas	P	NS		NS		NS	
Canal Zone:	Cristobal[e]	P	0	2	0 (4)	1	4 (4)	13
Puerto Rico:	San Juan[e]	P	4	4	0 (4)	0	5 (4)	7
PMN network average			8	8	0	0	9	10

[a] P, pasteurized milk; R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.
[d] Radionuclide analysis not routinely performed.
[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [e].
NA, no analysis.
NS, no sample collected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Table 4. Strontium-89 in milk, June 1969

Sampling location		Strontium-89 (pCi/liter)
D.C:	Washington	7 (2)
Ky:	Louisville	7 (2)
La:	New Orleans	10 (2)
Miss:	Jackson	7 (2)
Mo:	Kansas City	9
N. Dak:	Minot	7
Okla:	Oklahoma City	8 (2)
Ore:	Portland	6
S. Dak:	Rapid City	9
Tenn:	Chattanooga	8 (2)
	Memphis	8 (2)
Tex:	Austin	5 (3)
	Dallas	8 (3)
Wash:	Seattle	11
	Spokane	9

Strontium-90 monthly averages ranged from 0 to 31 pCi/liter in the United States for the month of June 1969 and the highest 12-month average was 20 pCi/liter at Little Rock Ark., Del Norte, Calif., and, Duluth, Minn., representing 10.0 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 126 pCi/liter in the United States for the month of June 1969 and the highest 12-month average was 111 pCi/liter at southeast Florida representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine results for individual samples were all below the practical reporting level, except Chattanooga, Tenn.(State), 3 pCi/liter, 5 samples.

Acknowledgment

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational, and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).
(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).
(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).
(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).
(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, strontium 89, and strontium-90 measurements in milk, December 1968. Technical Experiment 68-MAKU-2. Analytical Quality Control Service, Bureau of Radiological Health (December 1968).
(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).
(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).
(8) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
(9) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).
(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Fla. Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Radiostrontium in Milk[1], January-December 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii at the end of June 1965.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium-90 to calcium ratios in whole milk are presented in table 1.

[1] Data summarized from "Fallout Program Quarterly Summary Report," HASL-207 App., available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1966	September 1967
January–December 1967	August 1968

Table 1. Strontium-90 to calcium ratios in milk, January–December 1968

Sampling location	Strontium–90 to calcium ratio (pCi/g)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)	7.0	7.6	7.4	7.8	7.8	12.7	11.6	10.2	9.0	8.6	9.4	8.5
Perry, N.Y. (powdered whole milk)	6.2	5.7	6.7	5.7	6.9	9.8	8.8	8.9	7.4	7.3	6.8	6.3

Food and Diet Surveillauce

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Tri-City Diet, *HASL*	January–June 1968	April 1969

---

1. Radionuclides in Institutional Diet Samples January–March 1969 and Annual Summary 1968

Bureau of Radiological Health and
Bureau of Compliance, Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Compliance, Food and Drug Administration.

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and eight auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen

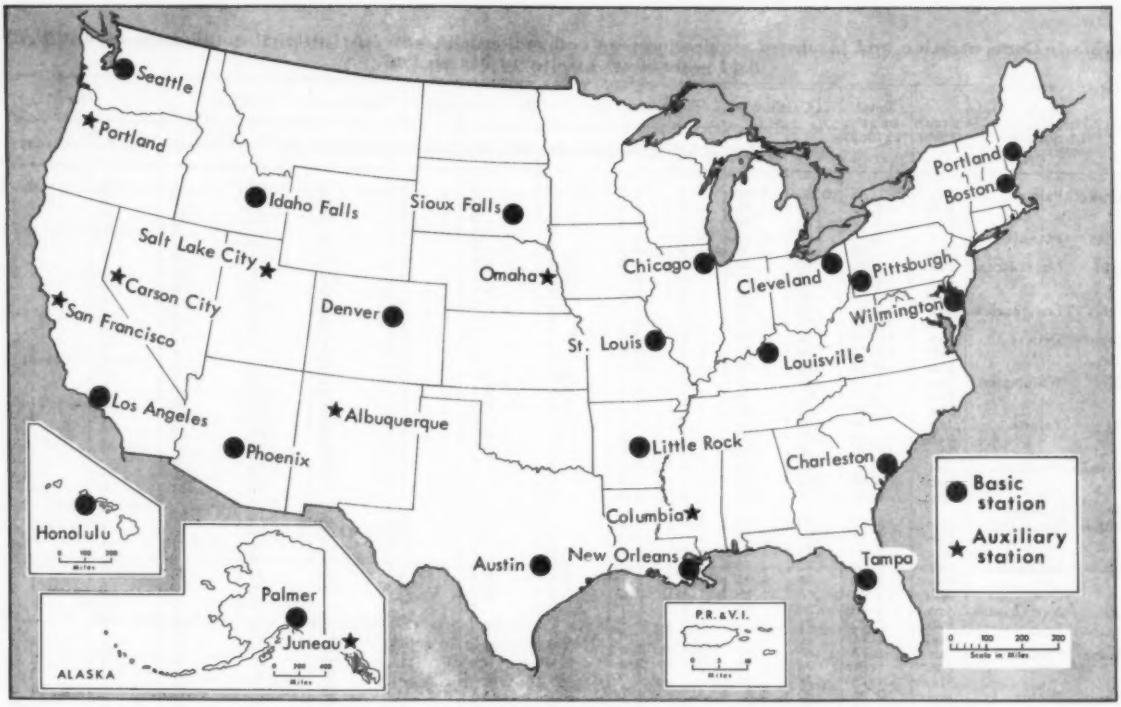

Figure 1. Institutional diet sampling locations as of March 1969

until the end of the collection period and is then packed in dry ice and shipped by air express to either the southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1969, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.90 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1968.

Strontium-90 dietary intake during this period averaged 15 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium-137 intakes averaged 21 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Table 1. Concentration and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age), January–March 1969

Location of Institution	Month (1969)	Total weight (kg/day)	Calcium		Potassium		^{89}Sr		^{90}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Palmer	Jan	1.85	0.56	1.04	1.2	2.2	0	0	5	8	0	0	0.3	0.6
	Feb	[a] 1.32	.63	.83	1.5	2.0	0	0	2	3	0	0	.6	.8
	Mar	1.17	.71	.83	1.6	1.9	0	0	10	12	12	14	.6	.7
Ariz: Phoenix[b]	Jan	1.68	.97	1.63	2.1	3.5	6	10	5	9	0	0	.4	.7
	Mar	1.94	.56	1.09	1.5	3.0	0	0	4	7	0	0	.5	1.0
Ark: Little Rock	Jan	1.56	.36	.56	1.2	1.9	NA	NA	6	10	0	0	.6	.9
	Feb	1.41	.58	.82	1.6	2.3	NA	NA	14	20	16	23	.7	1.0
	Mar	1.40	.45	.63	1.3	1.9	NA	NA	8	11	0	0	.3	.4
Calif: Los Angeles[c]	Feb	[a] 1.50	.35	.53	1.0	1.6	0	0	0	0	0	0	.4	.6
	Mar	[a] 2.22	.57	1.27	1.5	3.2	0	0	3	7	0	0	.4	.9
Colo: Denver	Jan	[a] 2.19	.93	2.04	1.7	3.8	0	0	8	17	0	0	.5	1.1
	Feb	[a] 2.17	.79	1.71	1.6	3.5	0	0	5	11	0	0	.6	1.3
	Mar	[a] 2.44	.74	1.81	1.5	3.7	0	0	4	10	0	0	.4	1.0
Del: Wilmington	Jan	2.15	.72	1.55	2.0	4.3	NA	NA	8	17	0	0	.3	.6
	Feb	2.17	.62	1.35	1.8	3.9	NA	NA	6	13	12	26	.7	1.5
	Mar	2.33	.61	1.42	1.5	3.5	NA	NA	6	14	11	26	.6	1.4
Fla: Tampa	Jan	1.39	.52	.72	1.5	2.1	NA	NA	10	13	17	24	.9	1.3
	Feb	[a] 1.18	.67	.79	1.6	1.8	NA	NA	8	9	24	28	.6	.7
	Mar	[a] 1.20	.65	.78	1.4	1.7	NA	NA	8	10	28	34	.7	.8
Hawaii: Honolulu	Jan	[a] 2.41	NA	NA	1.4	4.1	0	0	5	12	16	39	.4	1.0
	Feb	2.86	NA	NA	1.4	4.0	0	0	4	12	23	66	.5	1.4
	Mar	2.86	NA	NA	1.4	4.0	0	0	4	11	11	31	.6	1.7
Ill: Chicago[d]														
Idaho: Idaho Falls	Jan	[a] 1.93	1.00	1.93	2.0	3.9	0	0	8	15	19	37	.6	1.2
	Feb	2.17	1.54	3.34	1.6	3.5	0	0	13	28	16	35	.7	1.5
	Mar	2.04	.75	1.53	1.7	3.5	0	0	6	12	15	31	.4	.8
Ky: Louisville	Jan	2.23	.70	1.56	1.6	3.7	NA	NA	8	17	0	0	1.1	2.5
	Feb	1.64	.75	1.23	1.6	2.7	NA	NA	10	16	12	20	1.2	2.0
	Mar	[a] 1.63	.66	1.08	1.5	2.5	NA	NA	6	10	0	0	.8	1.3
La: New Orleans	Jan	1.60	.26	.42	1.3	2.1	0	0	7	11	0	0	.5	.8
	Feb	2.02	.51	1.03	1.7	3.4	0	0	9	18	11	22	.4	.8
	Mar	2.11	.56	1.18	1.7	3.5	0	0	9	19	12	25	.3	.6
Maine: Portland	Jan	1.77	.83	1.47	2.3	4.0	NA	NA	12	21	23	41	.7	1.2
	Feb	1.81	.94	1.70	2.1	3.8	NA	NA	11	20	20	36	.7	1.3
	Mar	1.78	.78	1.39	1.7	3.0	NA	NA	12	21	30	53	.7	1.2
Mass: Boston	Jan	2.26	.60	1.36	2.1	4.7	NA	NA	8	18	16	36	.5	1.1
	Feb	1.85	.72	1.33	1.7	3.1	0	0	10	19	22	41	.5	.9
	Mar	2.27	.59	1.34	1.9	4.3	0	0	8	18	18	41	.6	1.4
Mo: St. Louis	Jan	[a] 2.60	1.00	2.60	2.1	5.5	NA	NA	7	18	0	0	1.0	2.6
	Feb	[a] 1.98	1.09	2.16	1.9	3.8	NA	NA	8	16	17	34	.6	1.2
	Mar	[a] 2.54	.94	2.39	1.6	4.1	NA	NA	9	23	13	33	.9	2.3
Ohio: Cleveland	Jan	1.58	.63	1.00	2.0	3.1	NA	NA	8	13	0	0	.6	.9
	Feb	1.71	1.01	1.73	1.9	3.2	NA	NA	13	22	0	0	.6	1.0
	Mar	1.66	.65	1.08	1.6	2.7	NA	NA	5	8	0	0	.5	.8
Pa: Pittsburgh[e]	Jan	2.31	.57	1.32	1.7	3.8	NA	NA	8	18	0	0	1.1	2.5
	Feb	2.29	.53	1.21	1.5	3.4	NA	NA	7	16	12	27	.5	1.1
	Mar	2.33	.53	1.23	1.5	3.5	NA	NA	6	14	14	33	.5	1.2
S.C: Charleston	Jan	1.86	.70	1.30	1.6	3.0	0	0	9	17	17	32	.6	1.1
	Feb	2.18	.73	1.59	1.4	3.0	0	0	11	25	12	26	.6	1.3
	Mar	1.30	.72	0.94	1.4	1.8	0	0	9	12	16	21	.9	1.2
S.Dak: Sioux Falls	Jan	[a] 1.43	.67	0.96	1.7	2.5	NA	NA	8	11	0	0	.8	1.1
	Feb	[a] 1.46	.67	0.98	1.4	2.0	NA	NA	6	9	0	0	.7	1.0
	Mar	[a] 1.83	.59	1.08	1.6	2.9	NA	NA	6	11	14	26	.8	1.5
Tex: Austin	Jan	[a] 1.88	.84	1.58	1.7	3.3	NA	NA	5	9	0	0	.4	.8
	Feb	[a] 2.02	.80	1.62	1.7	3.4	NA	NA	6	12	0	0	.4	.8
	Mar	[a] 1.93	.76	1.47	1.4	2.7	NA	NA	4	8	0	0	.5	1.0
Wash: Seattle	Jan	[a] 2.00	.60	1.20	1.3	2.6	0	0	7	13	23	46	.5	1.0
	Feb	[a] 1.93	.90	1.74	1.6	3.1	0	0	8	16	0	0	.7	1.4
	Mar	[a] 1.81	.71	1.29	1.4	2.6	0	0	5	9	14	25	.5	.9
Institutional average	Jan	1.90	0.62	1.15	1.7	3.3	2	3	7	13	6	13	0.6	1.2
	Feb	1.99	0.71	1.33	1.7	3.3	0	0	10	18	14	29	0.6	1.2
	Mar	1.92	0.62	1.11	1.6	3.0	0	0	7	13	11	22	0.6	1.1

[a] Since food samples were collected from two or more children who were not between the ages of 9 to 12, data for this month were not used in institutional average.
[b] The samples for Phoenix, Ariz. were not collected for the month of February.
[c] Sample for January in Los Angeles, Calif., area was not collected due to flooding.
[d] Samples were not collected from the Chicago, Ill. area during this period.
[e] Iodine–131 was reported in the sample for February for Pittsburgh; 12 pCi/kg and 27 pCi/day.
NA, no analysis.
Note: Iodine–131 and barium–140 were not detectable at most stations during the first quarter of 1969 therefore no provision was made for the nuclides in the table except the above.

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing

Table 2. Concentration and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations), January–March 1969

Location of Institution	Month (1969)	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{89}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	Jan	1.34	0.63	0.84	1.4	1.8	0	0	8	11	12	16	0.3	0.4
	Feb	1.14	.40	.46	1.2	1.4	0	0	6	7	0	0	.3	.3
	Mar	1.60	.59	.94	1.2	2.0	0	0	9	14	0	0	.5	.8
Calif: San Francisco	Jan	2.39	.47	1.12	1.5	3.7	0	0	4	9	0	0	.2	.5
	Feb	2.36	.47	1.11	1.5	3.5	0	0	0	0	0	0	.5	1.2
	Mar	1.63	.42	.68	1.3	2.0	0	0	4	6	0	0	.5	.8
Miss: Columbia	Jan	2.24	1.10	2.46	1.5	3.4	NA	NA	12	27	12	27	.7	1.6
	Feb	2.07	.93	1.93	1.5	3.1	NA	NA	9	19	19	39	.5	1.0
	Mar	1.88	.88	1.65	1.5	2.9	NA	NA	8	15	12	23	.6	1.1
Nev: Carson City	Jan	1.80	1.02	1.84	1.8	3.3	0	0	4	7	12	22	.6	1.1
	Feb	1.47	.63	.93	1.5	2.2	0	0	0	0	0	0	.4	.6
	Mar	1.40	.68	.95	1.3	1.8	0	0	4	5	0	0	.6	.8
N. Mex: Albuquerque	Jan	2.57	.78	2.00	1.8	4.5	NA	NA	5	12	0	0	.4	1.0
	Feb	2.31	.83	1.92	1.4	3.2	NA	NA	3	6	0	0	.4	.9
	Mar	2.30	.76	1.75	1.4	3.1	NA	NA	4	8	0	0	.4	.9
Ore: Portland	Jan	1.56	.53	.83	1.8	2.9	8	12	8	12	0	0	.5	.8
	Feb	1.73	.56	.97	1.9	3.3	0	0	2	4	0	0	.4	.7
	Mar	1.72	.57	.98	1.7	2.9	0	0	3	6	0	0	.6	1.0
Utah: Salt Lake City	Jan	1.86	.53	.99	1.3	2.4	0	0	3	5	0	0	.3	.6
	Feb	1.66	.55	.91	1.2	1.9	0	0	2	4	0	0	.3	.5
	Mar	1.98	.44	.87	1.1	2.1	0	0	3	7	0	0	.5	1.0
Institutional average	Jan	1.97	0.72	1.44	1.6	3.1	2	2	6	12	5	9	0.4	0.8
	Feb	1.82	0.62	1.17	1.5	2.7	0	0	3	6	3	6	0.4	0.7
	Mar	1.79	0.62	1.12	1.3	2.4	0	0	5	9	2	3	0.5	0.9

NA, no analysis.

Table 3. 1968 annual average concentration and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age)

Location of Institution	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
		(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Palmer	1.60	0.6	0.9	1.4	2.2	8	13	17	26	0.5	0.8
Ariz: Phoenix	2.00	.6	1.2	1.3	2.6	4	9	4	8	.5	1.0
Ark: Little Rock	1.67	.5	.9	1.5	2.1	10	17	6	10	.5	.8
Calif: Los Angeles	1.64	.5	.8	1.3	2.0	4	7	2	4	.5	.9
Colo: Denver	2.33	.7	1.6	1.5	3.4	6	13	9	21	.5	1.1
Del: Wilmington	2.13	.7	1.4	1.6	3.5	8	17	7	16	.7	1.5
Fla: Tampa	1.77	.5	1.0	1.7	3.0	8	12	32	57	.6	1.1
Hawaii: Honolulu	2.30	.5	1.1	1.5	3.1	3	7	14	33	.4	1.0
Idaho: Idaho Falls[a]	2.03	1.1	2.2	1.8	3.2	9	19	15	20	.5	1.0
Ill: Chicago[b]	1.49	.7	1.1	1.6	2.4	6	10	16	24	.7	1.1
Ky: Louisville	1.45	.6	.9	1.6	2.3	9	12	2	4	.7	1.0
La: New Orleans	1.82	.6	1.1	1.6	3.0	11	21	15	28	.4	.8
Maine: Portland	1.65	.8	1.3	1.6	2.7	13	21	25	41	.7	1.2
Mass: Boston	1.79	.6	1.2	1.5	2.7	8	14	17	40	.6	1.0
Mo: St. Louis	2.52	1.0	2.6	1.7	4.2	10	24	12	30	.7	1.9
Ohio: Cleveland	1.48	.7	1.0	1.7	2.4	7	11	14	22	.7	1.0
Pa: Pittsburgh	2.23	.6	1.2	1.5	3.2	8	18	10	22	.7	1.6
S.C: Charleston	1.59	.7	1.1	1.5	2.3	10	15	20	31	.7	1.2
S.Dak: Sioux Falls	1.41	.8	1.1	1.5	2.1	8	11	11	16	1.0	1.4
Tex: Austin	1.80	.7	1.2	1.5	2.7	5	8	3	6	.4	.8
Wash: Seattle[a]	1.93	.6	1.1	1.6	3.0	6	11	11	20	.5	1.0
Institutional average	1.83	0.7	1.2	1.5	2.7	8	14	12	23	0.6	1.1

[a] This data was not included in the institutional average since all children were not between 9 to 12 years of age.
[b] This data only includes samples collected during the first 7 months of the year due to the termination of sampling at this location. There is a problem in finding a new institution.

environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Annual averages

Annual average radionuclide concentrations and intakes are presented in tables 3, 4, and 5 for the basic and auxiliary stations. During 1968, the annual average intake for the basic stations was 1.83 kg/day as compared to 1.86 kg/day in the auxiliary stations. The levels of radionuclide intake in both the basic and auxiliary stations were similar.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
April–June 1968	January 1969
July–September 1968	April 1969
October–December 1968	July 1969

Table 4. Strontium-89, iodine-131, and barium-140 average annual concentrations in Institutional total diets of children (9–12 years of age) 1968 not reported in table 3

Location of Institution	Month 1968	Strontium-89 (pCi/kg)	Iodine-131 (pCi/kg)	Barium-140 (pCi/kg)
Idaho	Jan.			14
Nebr:	Feb.		11	
Colo:	Mar.	6		
Nebr:				12
Idaho				17
Ohio	Apr.		13	15
Del:	June			17
Idaho:	July	6		
Mass:				20
Del:	Aug.			19
Maine:				14
Mo:	Sept.			20
Ohio:				21
Pa:				11
Maine:	Oct.			19
Idaho:	Nov.			11
Mass:			11	14
S. Dak:			12	13
Idaho	Dec.		14	15
Maine			14	

REFERENCES

(1) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in Institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in Institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Table 5. 1968 annual average concentration and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations)

Location of Institution	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
		(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	1.26	0.6	0.7	1.7	2.0	7	10	14	17	0.4	0.6
Calif: San Francisco	2.23	.8	1.5	1.6	3.6	5	10	6	13	.6	1.3
Miss: Columbia	2.11	.8	1.8	1.5	2.7	11	24	13	26	.5	1.2
Nebr: Omaha	2.30	.9	2.0	1.6	3.5	7	15	7	15	1.0	2.1
Nev: Carson City	1.57	.7	1.1	1.6	2.6	5	7	9	15	.6	.9
N.Mex: Albuquerque	2.02	.6	1.4	1.6	3.1	5	9	0	0	.4	.9
Oregon: Portland	2.28	.6	1.3	1.8	4.2	5	12	17	39	.5	1.1
Utah: Salt Lake City	1.17	.9	1.2	1.3	2.5	5	10	8	9	.4	.8
Institutional average	1.86	0.7	1.4	1.6	3.0	6	12	9	17	0.6	1.1

[a] Since strontium–89, iodine–131, and barium–140 were not detected at most stations during the year 1968, no provision was made for these radionuclides in the table. The exceptions for strontium–89 are as follows:

January 1968: 9 pCi/kg was reported in Portland, Ore.
April 1968: 7 pCi/kg was reported in San Francisco, Calif. and 10 pCi/kg was reported in Portland, Ore.
November 1968: 6 pCi/kg was reported in San Francisco, Calif.

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–June 1968	April 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U. S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States March 1969

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or

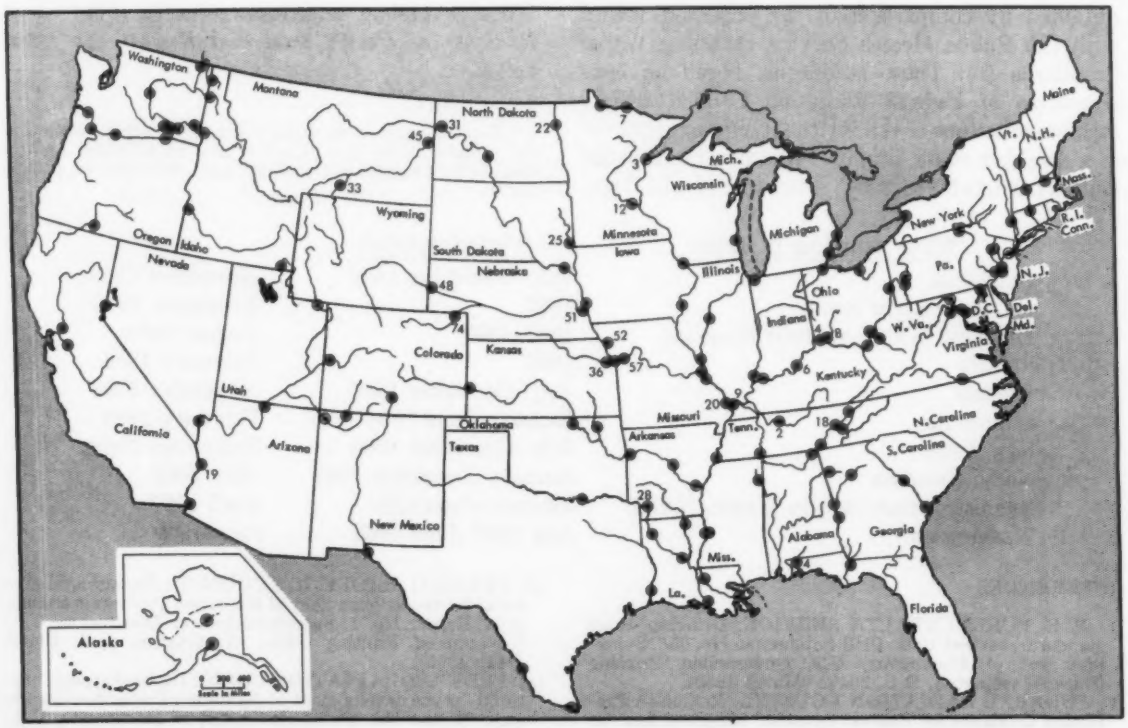

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, March 1969

Table 1. Radioactivity in raw surface waters, March 1969

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Big Horn River:						
Hardin, Mont.	3	3	6	13	20	33
Big Sioux River:						
Sioux Falls, S. Dak.	<1	12	12	4	31	35
Clinch River:						
Kingston, Tenn.[a]	0	<1	<1	2	16	18
Colorado River:						
Parker Dam, Calif–Ariz.	0	0	0	0	19	19
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	0	2	2
Escambia River[b]						
Century, Fla.	1	0	1	3	4	7
Great Lakes:						
Duluth, Minn.	0	0	0	1	2	3
Kansas River:						
DeSoto, Kans.	5	2	7	25	11	36
Little Miami River:						
Cincinnati, Ohio	0	1	1	1	7	8
Mississippi River:						
St. Paul, Minn.	0	1	1	1	11	12
Cape Girardeau, Mo.	3	2	5	12	8	20
Missouri River:						
Williston, N. Dak.	2	5	7	10	21	31
St. Joseph, Mo.	10	3	13	42	10	52
Missouri City, Mo.	10	2	12	48	9	57
North Platte River:						
Henry, Nebr.	1	32	33	14	42	56
Ohio River:						
Cincinnati, Ohio	0	<1	<1	<1	4	4
Louisville, Ky.	0	0	0	2	4	6
Cairo, Ill.	1	0	1	2	7	9
Platte River:						
Plattsmouth, Nebr.	11	3	14	35	16	51
Rainy River:						
International Falls, Minn.	0	0	0	0	7	7
Red River North:						
Grand Forks, N. Dak.	0	0	0	2	20	22
Red River South:						
Index, Ark.	5	1	6	19	9	28
South Platte River:						
Julesburg, Colo.	2	39	41	12	62	74
Yellowstone River:						
Sidney, Mont.	5	3	8	24	21	45
Maximum	11	39	41	48	62	74
Minimum	0	0	0	0	2	2

[a]Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.
[b]Quarterly composite sample, January–March 1969.

towards these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations in the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During March 1969, the following stations showed alpha radioactivity values in excess of 15 pCi/liter for dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

None of the stations showed a gross beta radioactivity in excess of 150 pCi/liter during March 1969.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL 80th Meridan Network	July–December 1967	September 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network June 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1969

Station location		Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	7	1	2	July 69	4	40	4	40	32
Alaska:	Adak	21	2	1	1	Feb 69	[c]				
	Anchorage	[b]				Aug 69	[c]				
	Attu Island	19	1	0	0	Mar 69	[c]				
	Fairbanks	[b]				Sept 69	[c]				
	Juneau	19	1	0	0	Dec 68	5	57	5	57	0
	Kodiak	[b]				Jan 69	[c]				
	Nome	[b]				May 69	[c]				
	Point Barrow	30	0	0	0	Apr 69	[c]				
	St. Paul Island	[b]				June 69	[c]				
Ariz:	Phoenix	21	7	2	3	Dec 68	[c]				
Ark:	Little Rock	2	2	0	1	Aug 69	[c]				
Calif:	Berkeley	21	2	0	0	Jan 69	[c]				
	Los Angeles	21	1	0	0	May 69	[c]				
C.Z:	Ancon	7	0	0	0	Jan 69	[c]				
Colo:	Denver	18	6	0	2	Jan 69	5	43	[d]		
Conn:	Hartford	17	0	0	0	Sept 69	6	65	5	64	4
Del:	Dover	19	1	0	1	July 69	[c]				
D.C:	Washington	31	3	0	1	Apr 69	6	29	6	29	23
Fla:	Jacksonville	19	1	0	1	Aug 69	6	135	6	135	58
	Miami	16	1	0	0	Sept 69	9	214	9	214	0
Ga:	Atlanta	20	3	1	2	June 69	1	23	1	23	23
Guam:	Agana	[b]				July 69	[c]				
Hawaii:	Honolulu	28	2	0	1	Mar 69	[c]				
Idaho:	Boise	22	3	0	1	Mar 69	6	60	6	60	5
Ill:	Springfield	20	5	1	2	Apr 69	[c]				
Ind:	Indianapolis	22	5	0	2	June 69	8	85	8	85	33
Iowa:	Iowa City	16	3	0	1	Jan 69	8	202	8	202	0
Kans:	Topeka	21	3	0	1	Aug 69	10	216	10	216	30
Ky:	Frankfort	14	3	1	1	Apr 69	[c]				
La:	New Orleans	15	1	0	1	Apr 69	6	33	[d]		
Maine:	Augusta	5	1	0	0	May 69	1	1	1	1	0
Md:	Baltimore	21	3	0	1	Sept 69	2	20	2	20	19
	Rockville	11	1	0	1	Mar 69	[c]				
Mass:	Lawrence	11	2	0	1	July 69	1	7	1	7	3
	Winchester	20	3	0	1	Feb 69	5	54	5	54	0
Mich:	Lansing	21	2	0	1	Mar 69	11	100	11	100	92
Minn:	Minneapolis	21	2	0	1	July 69	8	91	8	91	12
Miss:	Jackson	18	4	0	1	May 69	[c]				
Mo:	Jefferson City	21	2	0	1	June 69	10	212	10	212	0
Mont:	Helena	15	6	1	3	Feb 69	5	4	5	4	6
Nebr:	Lincoln	14	7	1	4	June 69	5	61	5	61	15
Nev:	Las Vegas	18	4	0	2	Sept 69	[c]				
N.H:	Concord	15	2	0	1	Apr 69	[c]				
N.J:	Trenton	21	2	0	1	May 69	5	75	5	75	31
N. Mex:	Santa Fe	10	3	1	1	Feb 69	1	21	1	21	25
N.Y:	Albany	[b]				June 69	[c]				
	Buffalo	21	2	0	1	Jan 69	[c]				
	New York City	20	1	0	0	Feb 69	[c]				
N.C:	Gastonia	17	9	1	4	Jan 69	4	16	[d]		
N. Dak:	Bismarck	20	3	0	1	Apr 69	8	73	8	73	0
Ohio:	Cincinnati	[b]				July 69	[c]				
	Columbus	19	3	0	1	May 69	6	157	0	0	[e]
	Painesville	21	5	1	1	Sept 69	9	123	9	123	41
Okla:	Oklahoma City	19	3	0	1	Mar 69	2	64	2	64	4
	Ponca City	21	2	0	1	Sept 69	9	161	9	161	0
Ore:	Portland	21	2	0	1	June 69	9	63	9	63	3
Pa:	Harrisburg	[b]				June 69	[c]				
P.R:	San Juan	[b]				May 69	[c]				
R.I:	Providence	13	2	0	1	Mar 69	5	31	5	31	11
S.C:	Columbia	16	3	0	1	Feb 69	5	56	5	56	3
S. Dak:	Pierre	11	8	1	3	Dec 68	[c]				
Tenn:	Nashville	19	2	0	1	Mar 69	5	72	5	72	5
Tex:	Austin	17	7	1	3	July 69	1	21	[d]		
	El Paso	[b]				Apr 69	[c]				
Utah:	Salt Lake City	26	4	0	1	May 69	7	111	7	111	33
Vt:	Barre	13	3	1	1	Aug 69	12	225	12	225	63
Va:	Richmond	20	1	0	0	Aug 69	6	138	6	138	71
Wash:	Seattle	6	1	0	0	Aug 69	5	25	[d]		
	Spokane	11	2	0	1	July 69	[c]				
W. Va:	Charleston	19	4	0	1	Feb 69	9	37	9	37	5
Wisc:	Madison	19	1	0	1	Aug 69	12	220	12	220	39
Wyo:	Cheyenne	21	6	1	2	Sept 69	7	75	7	75	49
Network summary		1,112	9	0	1		6	82	6	90	21

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

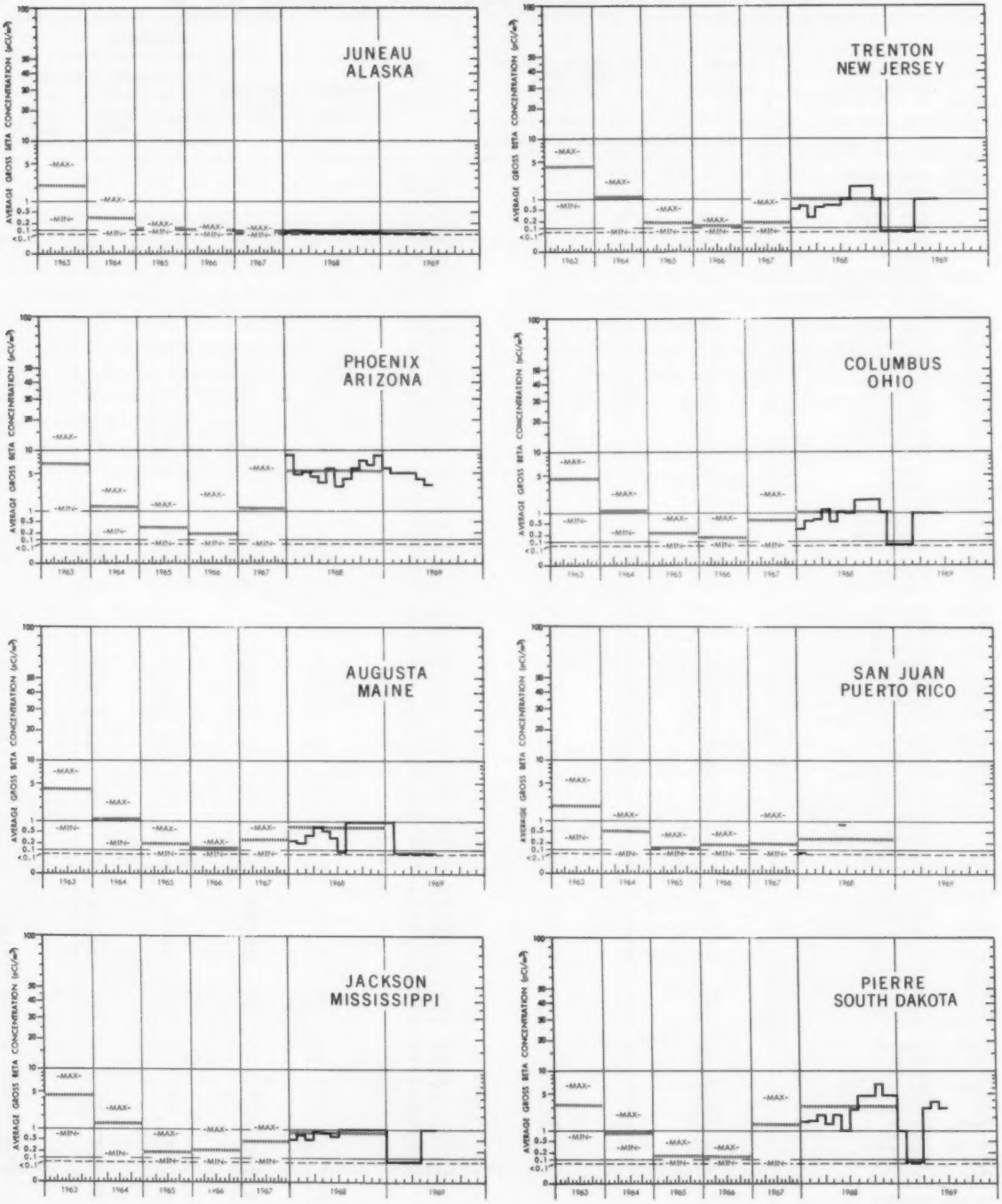

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–June 1969

2. Canadian Air and Precipitation Monitoring Program,[1] June 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the September 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for June 1969 are presented in table 2.

[1] Prepared from information and data in the July 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	14	0.6	0.1	0.4	55	7.0
Coral Harbour	29	.1	.0	.1	14	.2
Edmonton	30	.7	.1	.3	54	1.9
Ft. Churchill	25	.4	.0	.1	169	2.9
Ft. William	30	.3	.1	.2	172	9.8
Fredericton	28	.5	.0	.2	105	6.9
Goose Bay	27	.4	.0	.2	74	6.6
Halifax	30	.5	.0	.2	92	4.0
Inuvik	30	.3	.0	.1	426	2.1
Montreal	30	.6	.0	.3	78	9.2
Moosonee	28	.6	.0	.2	139	17.2
Ottawa	30	.6	.0	.3	146	13.4
Quebec	30	.5	.0	.2	94	10.9
Regina	30	.7	.1	.3	48	2.3
Resolute	29	.2	.0	.1	121	.3
St. John's, Nfld	28	.4	.0	.1	25	1.5
Saskatoon	30	.6	.1	.3	194	6.9
Saulte Ste Marie	30	.4	.0	.2	71	15.8
Toronto	30	.6	.0	.3	164	7.8
Vancouver	30	.7	.0	.2	96	1.6
Whitehorse	30	.9	.0	.4	191	5.2
Windsor	30	.6	.0	.2	103	13.4
Winnipeg	30	.4	.1	.3	167	17.5
Yellowknife	30	.4	.0	.2	290	3.1
Network summary	688	0.9	0.0	0.2	129	7.0

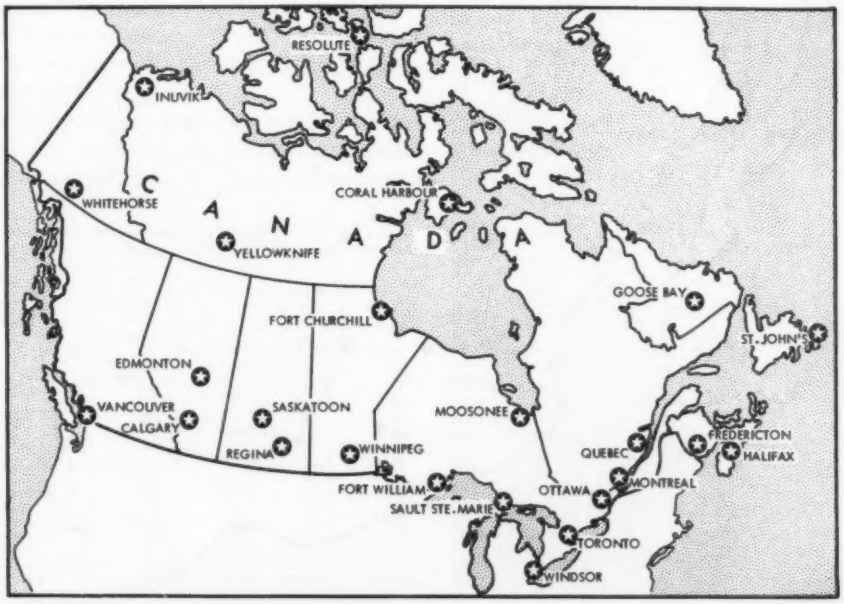

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program September–October 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Lius Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Déserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air

Table 3. Mexican gross beta radioactivity of airborne particulates, September 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	7	0.1	0.1	0.1
Chihuahua	15	.8	.1	.2
Ciudad Juarez	N8			
Ensenada	11	.3	.1	.2
Guadalajara	N8			
Guaymas	N8			
La Paz	13	.3	.1	.1
Matamoros	N8			
Mazatlan	1	.1	.1	.1
Mérida	15	.2	.1	.1
México, D.F.	N8			
Nuevo Laredo	12	.4	.2	.2
San Luis Potosi	N8			
Tampico	11	.1	.1	.1
Torreón	1	.1	.1	.1
Veracruz	14	.3	.1	.1

N8, no sample, station temporarily shutdown.

Figure 4. Mexican air sampling locations

through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week, at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Seccíon de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during September and October 1968 are presented in tables 3 and 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, October 1968

Station	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	11	0.1	0.1	0.1
Chihuahua	6	.2	.1	.2
Ciudad Juares	NS			
Ensenada	5	.2	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	7	.4	.1	.2
Matamoros	NS			
Mazatlan	NS			.1
Mérida	7	.2	.1	.1
México, D.F.	1	.9	.9	.9
Nuevo Laredo	1	.2	.2	.2
San Luis Potosi	NS			
Tampico	9	.3	<.1	.1
Torreón	2	.9	.8	.8
Veracruz	13	.6	.1	.2

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program June 1969

Pan American Health Organization and *U.S. Public Health Services*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. It should be noted that a new sampling station has been established in Cuenca, Ecuador.

Table 5. Summary of gross beta radioactivity in Pan American surface air, June 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	9	0.08	0.00	0.04
Bolivia:	La Paz	12	.33	.01	.12
Chile:	Santiago	28	.63	.03	.20
Colombia:	Bogota	17	.02	.00	.01
Ecuador:	Cuenca	11	.01	.00	.01
	Guayaquil	21	.33	.03	.12
	Quito	19	.25	.00	.08
Guyana:	Georgetown	10	.72	.06	.38
Jamaica:	Kingston	17	.56	.03	.19
Peru:	Lima	6	.13	.05	.08
Venezuela:	Caracas	17	.23	.01	.10
West Indies:	Trinidad	19	.28	.01	.13
Pan American summary		186	0.72	0.00	0.13

[a]The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The June 1969 air monitoring results from the participating countries are given in table 5.

Figure 5. Pan American Air Sampling Program stations

5. Fallout in the United States and Other Areas January–June 1968[2]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 36 sites in the United States and 103 locations in other countries. HASL data from all of the active United States stations and other selected points in the Western Hemisphere (figure 6) covering the period from January–June 1968 are summarized in tables 6 and 7. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposure area of 0.076 m^2. At the end of the collection period, the contents are transferred by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel with an exposed area of 0.072 m^2, attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*8*).

The analysis of monthly precipitation samples for other radionuclides that were being performed at laboratories in Westwood, N.J., New York City, N.Y., and Seattle, Wash., have been discontinued as of July 1967.

[2] The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL–204: A–5 to A–279 (January 1969). Plutonium analyses of monthly deposition are continuing at New York City and Melbourne, Australia.

Table 6. Strontium-90 fallout in the United States, HASL, January–June 1968

Sampling location		Type of collection	Deposition (nCi/m^2)					
			Jan	Feb	Mar	Apr	May	June
Ala:	Birmingham	pot	0.06	0.03	0.16	0.23	0.11	T
Alaska:	Anchorage	column	T	.07	.02	.02	.10	0.06
	Barrow	column	T	T	NS	NS	NS	.02
	Cold Bay	column	.14	.05	.04	.04	.09	.04
	Fairbanks	column	.03	T	T	T	.03	.09
	Juneau	column	.05	.11	.10	.08	NS	.02
	Nome	column	NS	T	T	.01	.02	.03
Calif:	W. Los Angeles	pot	.04	.04	.06	.04	.01	.01
	San Francisco	column	.09	.04	.08	T	.02	.01
Colo:	Denver	column	T	T	.02	.07	.13	.15
Fla:	Coral Gables	pot	.09	.06	.06	NS	NS	NS
	Miami	column	.04	.07	.05	.04	.29	.11
Hawaii:	Hilo	column	.08	.04	.37	.73	.13	.15
	Honolulu	pot	.08	.87	.38	.43	.20	.22
	Lihue	column	.05	.02	.15	.11	.02	.05
	Mauna Loa	column	.01	T	.05	.11	.02	.05
Ill:	Argonne	pot	.04	.05	.04	.18	.13	.15
La:	New Orleans	column	T	T	.01	.05	.04	.11
Minn:	International Falls	column	.02	T	.13	.08	.08	.19
Mo:	Columbia	column	.12	.02	.06	.10	.06	.16
Mont:	Helena	column	.01	T	.02	.06	.12	.25
N.J:	Westwood	pot	—	—	—	—	—	—
N.Y:	New York	pot	.07	.03	.14	.12	.32	.24
N. Dak:	Williston	column	T	T	.01	.03	.05	.29
Ohio:	Wooster	pot	.03	.01	.02	.07	.40	.16
Okla:	Tulsa	pot	.09	.03	.23	.29	.23	NS
Ore:	Medford	column	.08	.06	.06	.02	.09	.03
S.C:	Columbia	column	.07	.02	.08	.17	.09	.18
S.Dak:	Vermillion	pot	.02	.01	.07	.04	.13	.14
Tex:	Dallas	column	.02	.07	.18	.13	.11	.09
	El Paso	column	.03	.03	.05	.02	T	.02
	Houston	column	.10	.03	.09	.06	.26	.14
Utah:	Salt Lake City	pot	.01	.13	.30	.26	.34	.22
Va:	Sterling	column	.04	.02	.16	.12	.26	.24
Wash:	Seattle	pot	.13	.11	.17	.10	.20	NS
		pot	—	—	—	—	—	—
	Forks	column	.30	.21	.32	.30	.13	.13
Wisc:	Green Bay	column	.04	T	.08	.28	.32	.31

T, trace or zero.
NS, no sample.

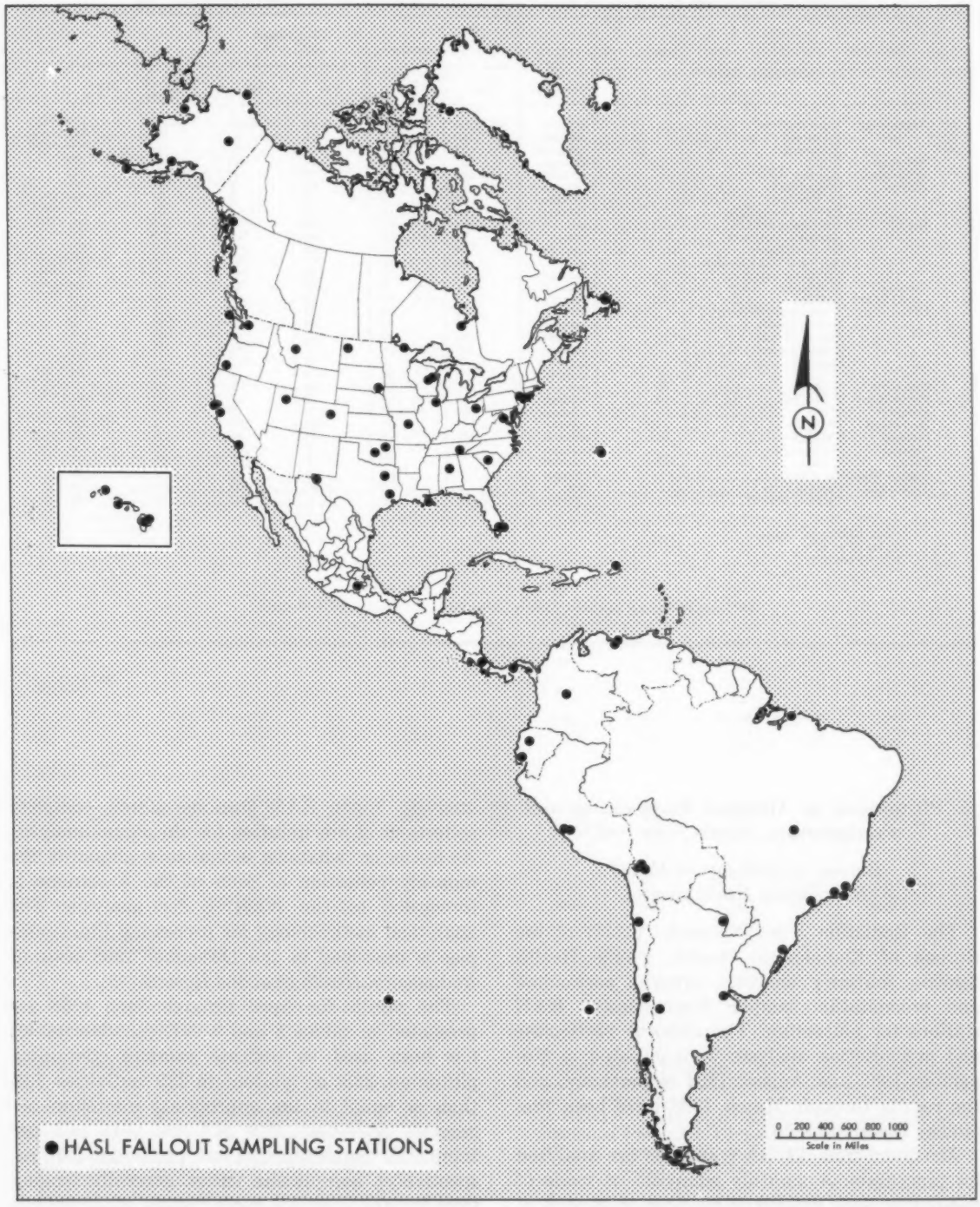

Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 7. Strontium-90 fallout in North and South America, HASL, January–June 1968

Sampling location		Type of colection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires	column	0.05	0.05	0.02	0.01	0.01	NS
	Formosa	column	.02	T	T	.01	.01	NS
	Malargue	column	.02	.02	.02	.01	.01	NS
Bahamas:	Bimini	column	.01	.05	.25	.02	NS	.09
Bermuda:	Kindley AFB	column	.06	.30	.04	.14	.09	.02
Bolivia:	Chacaltaya	column	.01	T	.01	T	.01	.01
	La Paz (city)	column	.02	T	T	T	.01	.02
	La Paz (Ovejuyo)	column	.01	.01	T	T	.01	.02
Brasil:	Itaici Sao Paulo	pot	.02	NS	NS	NS	NS	NS
	Nova Friburgo	pot	.02	.02	.01	NS	NS	NS
	Rio de Janeiro	column	.04	.05	.05	.06	NS	NS
	San Jose Dos Compos	pot	.01	NS	NS	NS	NS	NS
	Trindade Island	column	.02	.02	.05	NS	NS	NS
Canada:	Moosonee	column	T	T	.10	.16	.05	.23
Canal Zone:	Balboa	column	T	.02	.02	.03	.03	.02
Chile:	I. Alejandro Selkirk[a]	column	.02	.05	.04	.02	.01	NS
	Easter Island	column	.05	.01	.03	.02	.03	T
	Puerto Montt	column	.04	.03	.02	.03	.03	NS
	Punta Arenas	column	.01	.04	T	NS	.01	NS
	Santiago	pot	T	T	.05	T	.01	NS
		column	T	.02	.04	T	.01	.01
Colombia:	Bogota	pot	T	T	NS	T	.01	T
Costa Rica:	Turrialba	column	.03	.08	.18	.07	.03	.01
Ecuador:	Quito	column	NS	T	T	T	NS	NS
Greenland:	Thule	column	T	.01	.01	.01	.01	.04
Iceland:	Keflavik	column	NS	NS	NS	.10	.09	.08
Mexico:	Mexico City	column	.01	.01	T	.06	.06	.06
Peru:	Lima	column	T	T	T	T	.01	.01
Puerto Rico:	San Juan	column	T	.04	.12	.05	.11	.09
Venezuela:	Caracas (site 1)	column	T	T	.01	.02	.03	.03
	Caracas (site 2)	column	.01	T	T	.02	.03	.03

[a] Isla Robinson Crusoe.
T, trace or zero.
NS, no sample.

6. Plutonium in Airborne Particulates and Precipitation, April–June 1968

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and precipitation analyses were initiated in November 1965 and August 1966 respectively, and the results through March 1968 have been previously reported (*9–16*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter or (whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*15*).

The results for April through June 1968 are presented in tables 8 and 9. ND (nondetectable) has been used to indicate samples containing plutonium-238 or plutonium-239 activities less than or equal to the appropriate minimum detectable activities (.020 pCi and .015 pCi per sample for plutonium-238 and plutonium-239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples, and from 2 to 8 liters for the precipitation samples.

Table 8. Plutonium 238 and plutonium-239 in precipitation, April–June 1968

	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Honolulu	Seattle
Precipitation depth (mm)								
April	43	NS	NS	21	71	44	75	38
May	31	NS	NS	31	173	22	NS	75
June	18	NS	NS	18	80	17	8	15
Concentration (pCi/liter)								
Plutonium–239								
April	0.019			.017	.008	.010	ND	.005
May	ND			.009	.009	.023		.010
June	.005			.030	.005	.051	.017	.016
Plutonium–238								
April	.015			.006	ND	.003	NA	ND
May	.004			ND	NA	.007		NA
June	ND			.014	ND	.009	ND	.005
Deposition (pCi/m²)								
Plutonium–239								
April	.82			.36	.57	.44		.19
May				.28	1.56	.51		.75
June	.09			.54	.40	.87	.14	.24
Plutonium–238								
April	.65			.13		.13		
May	.12					.15		
June				.25		.15		.08

[a] The basic finding is the concentration (pCi/liter). This figure is multiplied by the depth of precipitation for the month (mm) to obtain the total deposition (pCi/m²). One liter of water is collected when 1 mm of precipitation falls on 1-square meter.

NS, no sample.
ND, nondetectable.
NA, no analysis.

Table 9. Plutonium in airborne particulates, April–June 1968

	Buffalo	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Anchorage	Phoenix	Honolulu	Seattle
Plutonium–238: (fCi/m³)											
April	0.008	0.014	NS	0.005	0.013	0.015	0.017	0.006	0.028	0.005	0.004
May	.005	.011	NS	.012	.013	.008	.015	ND	.021	.006	.007
June	.007	.011	NS	.007	.010	.003	.011	.005	.015	.006	.007
Plutonium–239: (fCi/m³)											
April	.030	.068	NS	.032	.069	.052	.095	.017	.120	.029	.019
May	.024	.050	NS	.055	.065	.038	.088	.007	.110	.028	.031
June	.044	.052	NS	.042	.049	.028	.062	.020	.090	.029	.032
$^{239}Pu/^{238}Pu$											
April	3.75	4.86		6.40	5.31	3.47	5.58	2.83	4.29	5.80	4.75
May	4.80	4.55		4.58	5.00	4.75	5.87		5.24	4.67	4.43
June	6.29	4.73		6.00	4.90	9.33	5.64	4.00	6.00	4.83	4.57

NS, no sample.
ND, nondetectable (see text).

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(6) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comision Nacional de Energia Nuclear, Direccion General de Seguridad Radiologica (1966).
(7) LOCKHART, L. B., Jr. and R. L. PATTERSON, Jr. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025. Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Radiol Health Data 5:12–15 (January 1964).
(8) RUSSELL, J., H. LEVINE, and R. SCHNEIDER. Plutonium in airborne particulates, November 1964 through March 1966. Radiol Health Data Rep 7: 483–485 (August 1966).
(9) DIVISION OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–June 1966. Radiol Health Data Rep 7:666–667 (November 1966).
(10) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, July–September 1966. Radiol Health Data Rep 8:108–109 (February 1967).
(11) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, October–December 1966. Radiol Health Data Rep 8:288–289 (May 1967).
(12) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, January–March 1967. Radiol Health Data Rep 8:534 (September 1967).
(13) LEVINE, H., W. P. KIRK, H. J. L. RECHEN. Plutonium and strontium-90 in precipitation, August 1966 through March 1967. Radiol Health Data Rep 8:574–576 (October 1967).
(14) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation and strontium-90 in precipitation, April–June 1967. Radiol Health Data Rep 8:662–663 (November 1967).
(15) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, July–December. Radiol Health Data Rep 9:761–763 (December 1968).
(16) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, January–March 1968. Radiol Health Data Rep 10:34–35 (January 1969).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Lawrence Radiation Laboratory and Shippingport Atomic Power Station.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory[2] January–December 1968

University of California
Berkeley, Calif.

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University, although there is some overlap (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

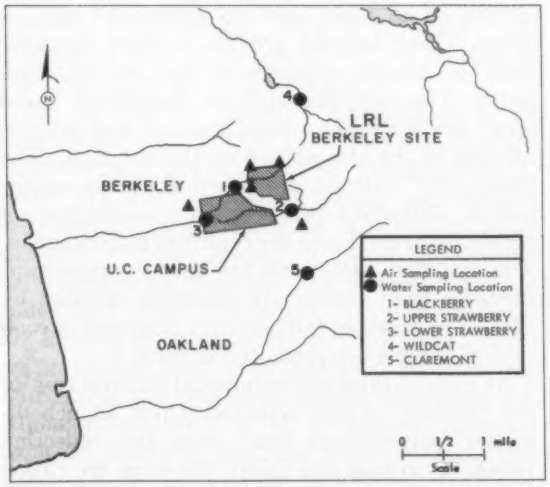

Figure 1. Environmental sampling locations at the Berkeley site, Lawrence Radiation Laboratory

[2] Summarized from "Results of Environmental Radioactivity Sampling Program, January–December 1968," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology, and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove-box manifolds are sampled. The total quantities released from these stacks during January–June 1968 were 1.0 mCi of alpha-particle emitters and 200 mCi of beta-particle emitters; July–December 1968 were 0.8 mCi of alpha-particle emitters and 290 mCi of beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 9 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

At each of these environmental stations rain or dry "fallout" is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 1. Atmospheric monitoring, LRL Berkeley Site January–December 1968

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		January–June	July–December	January–June	July–December
Local area (10)	503	0.001	0.001	0.27	0.09
Perimeter (4)	199	.001	.001	.32	.10

Table 2. Total deposition, LRL Berkeley Site January–June 1968

Sampling locations (number of locations)	Number of samples	Average deposition (nCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		January–June	July–December	January–June	July–December
Local area (10)	117	0.08	0.06	13.43	3.74
Perimeter (4)	48	.05	.10	14.05	4.63

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Small quantities of radioisotopes now and then are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha-plus-beta radioactivity) in sewage is only 28 percent for the period, January–June 1968 and 17 percent (July–December 1968), of the standard for drinking water and therefore does not constitute a serious exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope potassium-40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in table 3. Two nearby offsite streams are also sampled to

provide a comparison. All concentrations are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

Table 3. Water monitoring, LRL Berkeley site January–December 1967

Type and source of sample	Number of samples	Average concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		January–June	July–December	January–June	July–December
Sewage: Hearst sewer, Strawberry sewer	101	0.06	0.08	27.1	15.9
Tap water	51	.01	.07	1.91	1.58
Surface water:					
Onsite streams	153	.51	.24	6.13	6.26
Offsite streams	102	.38	.30	2.79	2.79

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in northern California—approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall for 1968 was 13.4 inches and the relative humidity is about 30 percent during the summer months and about 40–50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000 are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from one dairy in the Livermore Valley and from another dairy near Site 300. Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

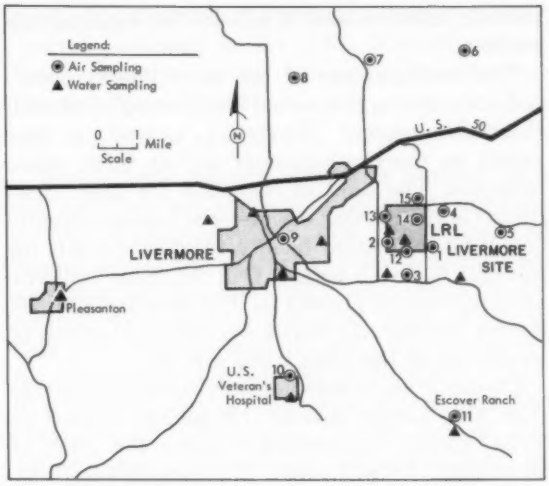

Figure 2. Environmental sampling locations at the Livermore site, Lawrence Radiation Laboratory

Air samples are collected continuously at 16 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas-flow proportional detectors for both alpha and beta radioactivity measurements. Alpha radioactivity in 462 air samples collected from 16 sampling locations averaged less than 0.040 pCi/m³. The average beta radioactivity was 0.096 pCi/m³. The applicable AEC radiation protection standards are 0.040 pCi/m³ for alpha-

particle emitters and 1 pCi/m³ for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at three offsite locations. The limit of detection for these dosimeters is 10 mR. One dosimeter at a point opposite cobalt-60 irradiation facility recorded 53 mR for the past 6 month period. One dosimeter opposite an experimental physics facility recorded 420 mR during the year. All others were below the limit of sensitivity or less than 0.005 mR/hr.

Domestic water samples were collected monthly from nine nearby sources. No sample showed an alpha specific radioactivity above the limit of sensitivity (5.0 pCi/liter). The beta radioactivity fluctuated from the limit of sensitivity (1.8 pCi/liter) to 26 pCi/liter. The average beta radioactivity concentration was 4.1 pCi/liter. The average alpha and beta radioactivity concentrations were below the respective standards of comparison of 10 and 100 pCi/liter stated in AEC standards.

The average tritium content was at or below the limit of sensitivity (5 pCi/liter), which is well below the standard of comparison of 3 μpCi/liter.

Samples were collected daily at the laboratory sewer discharge. The average concentration of radionuclides in the sewer effluent was 10 pCi/liter of alpha radioactivity and 128 pCi/liter of beta radioactivity. The tritium content of the effluent was 3 nCi/liter.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity fluctuated from the limit of sensitivity (1.5 pCi/g) to 22 pCi/g. The beta radioactivity fluctuated from the limit of sensitivity (3.5 pCi/g) to 20 pCi/g, averaging 7.4 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 3.2 pCi/liter of cesium-137 and ≤5 pCi/liter of cerium-141–144, for the two dairies. The average tritium concentration in milk was at or below the limit of sensitivity, (5 nCi/liter).

Site 300

The high explosive test area at Site 300 (figure 3) covers 10 square miles in the hills in a very sparsely populated ranching area about 15 miles southeast

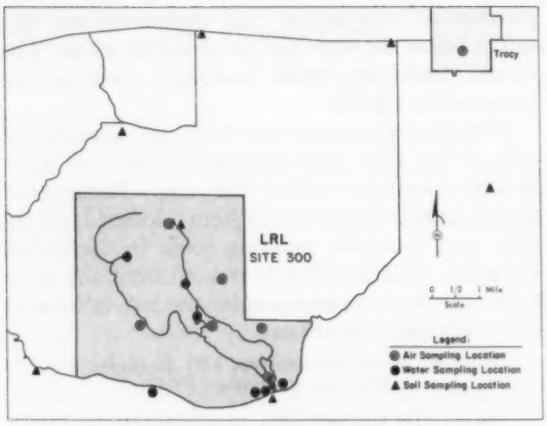

Figure 3. Sampling locations at Site 300, LRL

of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from onsite wells because they are the only readily accessible sources of underground water. No sample showed an alpha radionuclide concentration above the limit of sensitivity—5.0 pCi/liter. The beta concentration ranged from the limit of sensitivity (1.8 pCi/liter) to 51 pCi/liter, averaging 9.2 pCi/liter.

Soil samples are collected quarterly at nine offsite locations. The average alpha radioactivity was 2.0 pCi/g during the first 6 months and 1.5 pCi/g for the second half of 1968. The average beta radioactivity was 10 pCi/g.

None of the average concentrations of air, water, and soil samples exceeded the standards of comparison applicable to activities at the test site, nor did any of the results increase significantly compared to 1967 data. Therefore, it appears that radiological control measures at Site 300 were adequate and that no significant radioactivity was released to the environment near the site during this period.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1967	April 1968
July–December 1967	September 1968

2. Shippingport Atomic Power Station[2] January–December 1968

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River in a site consisting of over 400 acres. The site is about 25-miles northwest of Pittsburgh and about 11 miles below the confluence of the Beaver and Ohio Rivers (figure 4). The station is designed to produce electrical energy by a conventional central station type turbine-generator unit. The pressurized water reactor consists of a closed system in which water is circulated by pumps over an array of nuclear fuel elements, or core, contained in a reactor vessel, to heat exchangers where steam is formed in a separate isolated system.

Radioactive waste handled under the environmental program includes liquid and gaseous effluents released into the Ohio River and atmosphere, respectively. The levels of radioactivity released were below Shippingport discharge limits. These limits are based upon radiation standards set forth by AEC's division of Operational Safety in directives published in the AEC Manual[1], and a waste discharge permit from the Pennsylvania Sanitary Water Board.

[2] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the Calendar Year 1968."

Ohio River water analysis

During 1968, weekly composite samples were obtained from two continuous automatic samplers in the circulating-water line, upstream and downstream of the radioactive water effluent. Both suspended and dissolved materials in the composite samples were analyzed for gross alpha and gross beta radioactivity. Each composite is also analyzed for potassium-40 content. No significant difference was observed among the average alpha, beta, and potassium-40 radioactivity for the influent and effluent samples. The results of these analyses are presented in table 4.

Ohio River sediment analysis

Once during each calendar quarter, sediment samples of the Ohio River were collected upstream and downstream of the circulating water outfall. These samples were quantitated assuming all detected radioactivity to be cobalt-60, which is the major constituent of radioactive contamination at the station. The results of the sediment samples are presented in table 5. These data indicate that there was no increase of radioactivity in the river sediment as a result of the station's discharges.

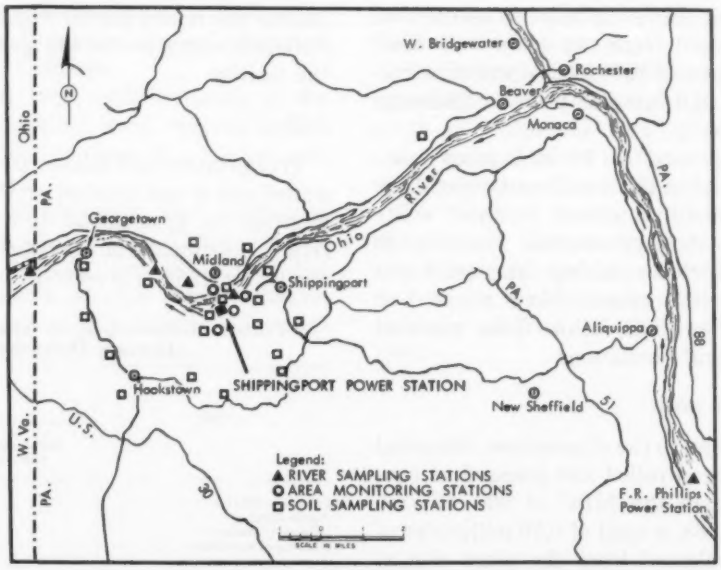

Figure 4. Shippingport Power Station sampling locations

Table 4. Gross radioactivity in the Ohio River, Shippingport January–December 1968

Type of radioactive material	Average concentration (pCi/liter)							
	Influent samples				Effluent samples			
	Jan–March	April June	July–Sept.	Oct–Dec.	Jan–March	April–June	July–Sept.	Oct–Dec.
Alpha:								
Total solids	0.89	1.2	0.61	0.83	1.4	1.1	0.84	0.79
Beta:								
Total solids	23	11	17	15	22	18	16	15
Potassium–40	3.2	3.8	6.5	5.7	3.3	3.9	6.6	5.6

Table 5. Total radioactivity in the Ohio River sediment samples, Shippingport, January–December 1968

1968	Number of samples	Gross radioactivity (pCi/g)	
		Upstream	Downstream
January–March	2	6.8	6.7
April–June	2	17	14
July–September	2	7.2	7.3
October–December	2	5.6	6.8

Liquid radioactive waste

The liquid radioactive wastes disposed of at Shippingport are primarily from the reactor coolant system. The radioactive waste produced by the plant is reduced in concentration in such a manner that the concentration of these wastes in water measured at the condenser water stream before discharge to the Ohio River, meets the limits as delineated above. In order to assure that the liquid discharged from the plant will meet specified tolerances, all radioactive waste is collected, processed, and sampled prior to discharge to the environment.

During 1968, a total of 75 mCi gross beta-gamma radioactivity in the liquid waste (exclusive of tritium) and 35 Ci of tritium in liquid waste were released into the environment. The average daily discharge of tritium during this period was 96 mCi. All reported concentrations released to the environment were well below those specified by State and Federal regulations.

Gaseous radioactive waste

Gaseous discharges to the atmosphere, identified as xenon-133, are controlled and released at concentrations less than the MPC of 300 nCi/m^3. During the year 1968, a total of 0.79 millicuries of xenon-133 were released from the plant site at less than the specified concentration.

Film badge monitoring

Twelve film badges for detecting beta-gamma radioactivity were posted continuously at the site perimeter in an attempt to determine the external radiation exposure in the immediate area. In order to accomplish this, a control film badge location was established at a point 10 miles from the station boundary.

During the first and third quarters of this report period, the mrem equivalent taken from the normal quarterly film badges was equal to that of the control film. However, during the second and fourth quarters, differences of readings between the control film and the quarterly site film at several locations ranged up to 20 mrem equivalent. A further check of these differences indicated that they resulted from activities being performed within the controlled area boundary. At no time during this report period was there any significant radiation exposure to the general public outside the facility.

Fallout

Precipitation and fallout are collected in a high-walled pot at one location on the site and analyzed monthly for gross alpha and gross beta radioactivity. A summary of the quarterly average fallout results for 1968 is presented in table 6.

Table 6. Radioactivity in fallout, Shippingport January–December 1968

1968	Deposition rate (nCi/m^2/month)	
	Alpha radioactivity	Beta radioactivity
January–March	0.17	15.03
April–June	.33	9.85
July–September	.15	7.35
October–December	.17	4.51
12-month average	0.20	9.18

Conclusion

From the data presented above, it may be concluded that during 1968 the radioactive effluent releases from the Shippingport station site did not cause any significant increase in background radiation levels. In this regard, the station procedures relative to controlling radioactive discharges to the environment are considered to be effective in protecting the health and safety of the general public.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1966	July 1967
January–December 1967	February 1969

Reported Nuclear Detonations, September 1969

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced on September 8, 1969 that the United States had recorded seismic signals originating from the southern Ural area. The signals were equivalent to those of a nuclear test in the low (less than 20 kilotons TNT equivalent) yield range.

A Plowshare gas-stimulation experimental nuclear test called Project Rulison was conducted by the Atomic Energy Commission on September 10, 1969. It was a 40-kiloton device detonated near Grand Valley, Colorado.

On September 11, 1969, seismic signals in the Semipalatinsk region also were recorded. The signals were equivalent to those of a nuclear test in the low yield range.

A nuclear test of low yield was conducted September 12, 1969, by the U.S. Atomic Energy Commission at its Nevada Test Site. After the detonation, instruments showed some radiation readings slightly above background. No radioactivity was detected off the test site.

A nuclear text was conducted underground on September 16, 1969 by the Atomic Energy Commission at its Nevada Test Site. It had a yield of less than 1 megaton.

The United States recorded seismic signals on September 22, 1969, which originated in the eastern Tien Shan Mountain Range adjacent to the Chinese nuclear test site of Lop Nor. The signals were equivalent to those of a nuclear test in the low-intermediate yield (20 to 200 kilotons TNT equivalent) range.

On September 26, 1969, seismic signals were recorded by the United States in the Soviet Union, south of Volgograd (Stalingrad). These signals also were equivalent to those of a nuclear test in the low-intermediate yield range.

The United States detected on September 29, 1969, a Chinese nuclear test in the lower atmosphere in the Lop Nor area. The detonation had a yield of about 3 megatons, similar to those of June 17, 1967, and December 27, 1968.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

EXPERIENCE OF THE STATE OF ILLINOIS DEPARTMENT OF PUBLIC HEALTH FOLLOWING THE ENACTMENT OF A LASER SYSTEM REGISTRATION LAW. *R. W. Courtney. Radiological Health Data and Reports, Vol. 10, September 1969*, pp. 421–426.

The experience of the State of Illinois Department of Public Health, following the enactment of a laser registration law, is presented. The priorities suggested for the inspection of laser systems are; (1) high energy laser systems applied in industrial processes; (2) lower energy laser systems used in outdoor processes that could potentially expose the general public; (3) lasers used in research institutions, and (4) lasers used as high school and college teaching instruments.

At the time of this report, only one accident had been reported to the Department of Health. This accident was a case of electrical shock in which there was no serious injury or loss of work time for the employee.

Keywords: Accidents, Illinois, industrial, inspection, laser systems, public exposure, registration law, research institutions, teaching institutions.

A COMPARISON OF THE CESIUM-137 CONTENT OF MILK AND PEOPLE FROM 19 DAIRY FARMS IN UTAH, 1962–1966. *R. D. Lloyd, C. W. Mays, R. C. Pendleton, and D. O. Clark. Radiological Health Data and Reports, Vol. 10, September 1969*, pp. 427–433.

Measured cesium-137 concentration (pCi ^{137}Cs/g K) in milk from 19 Utah dairy farms and in residents of those farms, have been compared for the period 1962 through 1966. During the time when cesium-137 levels were increasing (1962–1964), the cesium-137 to potassium ratios in people were similar to the ratios in milk produced by the dairy farm on which they resided. During the time when cesium-137 levels were decreasing (1964–1966) the ratios in people averaged about 2.5 to 4 times higher than the milk. Differences in biological half-times of cesium for men, women, and children, are reflected in their respective body concentrations of cesium-137. This comparison suggests that measured cesium-137 to potassium ratios of milk might be used to estimate the cesium-137 concentration of a population with similar dietary habits during a corresponding time period without considering such factors as milk intake or the consumption of non-milk foods. Preliminary analysis of the relationship between milk levels and body cesium-137 concentration of individual subjects indicates that milk cesium-137 data can be used with appropriate human biological half-times to estimate the shape of human cesium-137/potassium curves for the same time period.

Keywords: Body burdens, cesium-137, dairy farms, milk, potassium, residents, Utah.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check☐ for this subscription. ($6.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows._____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1969
For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $6.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

October 1969

GUIDE FOR AUTHORS

The editorial staff invites reports and technical notes containing information related to radiological health. Proposed reports and notes should contain data and interpretations. All accepted manuscripts are subject to copy editing with approval of the author. The author is responsible for all statements made in his work.

Manuscripts are received with the understanding that other identical manuscripts are not under simultaneous consideration nor have appeared in any other publication.

The mission of *Radiological Health Data and Reports* is stated on the title page. It is suggested that authors read it for orientation of subject matter.

Submission of manuscripts

Send original and one legible copy of the paper, typed double-spaced on 8½ by 11-inch white bond with 1-inch margins.

Submitted manuscripts should be sent to Managing Editor, Radiological Health Data and Reports, Bureau of Radiological Health, PHS, Rockville, Md. 20852.

Preparation of manuscripts

The Government Printing Office style manual is used as a general guide in the preparation of all copy for *Radiological Health Data and Reports*. In addition, *Radiological Health Data and Reports* has developed a "Guide" regarding manuscript preparation which is available upon request. However, for most instances, past issues of *Radiological Health Data and Reports* would serve as a suitable guide in preparing manuscripts.

Titles, authors: Titles should be concise and informative enough to facilitate indexing. Names of authors should appear on the third line below the manuscript title. Affiliation of each author should be given by a brief footnote including titles, professional connections at the time of writing, present affiliation if different, and present address.

Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

Methods: For analytical, statistical, and theoretical methods that have appeared in published literature a general description with references to sources is sufficient. New methods should be described clearly and concisely with emphasis on new features. Both old and new methods, materials, and equipment, should be described clearly enough so that limitations of measurements and calculations will be clear to the readers. Errors associated with analytical measurements and related calculations should be given either as general estimates in the text or for specific data in appropriate tables or graphs whenever possible.

Illustrations: Glossy photographic prints or original illustrations suitable for reproduction which help enhance the understanding of the text should be included with the manuscript. Graphic materials should be of sufficient size so that lettering will be legible after reduction to printed page size (8½ by 6½ inches).

All illustrations should be numbered and each legend should be typed double-spaced on a separate sheet of paper. Legends should be brief and understandable without reference to text. The following information should be typed on a gummed label of adhesive strip and affixed to the back of each illustration: figure number, legend, and title of manuscript or name of senior author.

Tables: Tables should be self-explanatory and should supplement, not duplicate, the text. Each table should be typed on a separate sheet, double-spaced. All tables must be numbered consecutively beginning with 1, and each must have a title.

Equations: All equations must be typewritten, preferably containing symbols which are defined immediately below the equation. The definition of symbols should include the units of each term. Special symbols, such as Greek letters, may be printed carefully in the proper size, and exponents and subscripts should be clearly positioned. Mathematical notations should be simple, avoiding when feasible such complexities as fractions with fractions, subscripts with subscripts, etc.

Symbols and units: The use of internationally accepted units of measurements is preferred. A brief list of symbols and units commonly used in *Radiological Health Data and Reports* is given on the inside front cover of every issue and examples of most other matters of preferred usage may be found by examining recent issues. Isotope mass numbers are placed at the upper left of elements in long series or formulas, *e.g.*, ^{137}Cs; however, elements are spelled out in text and tables, with isotopes of the elements having a hyphen between element name and mass number; *e.g.*, strontium-90.

References: References should be typed on a separate sheet of paper.

Personal communications and unpublished data should not be included in the list of references. The following minimum data for each reference should be typed double-spaced: names of all authors in caps, complete title of article cited, name of journal abbreviated according to *Index Medicus*, volume number, first and last page numbers, month or week of issue, and year of publication. They should be arranged according to the order in which they are cited in the text, and not alphabetically. All references must be numbered consecutively.

Reprints

Contributors are ordinarily provided with 50 courtesy copies of the articles in the form of reprints. In cases of multiple authorship, additional copies will be provided for coauthors upon request.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON, D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐; tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.